MAY 19 1924

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VOL. CXVII.—No. 3045.] LONDON: FRIDAY, MAY 9, 1924. [Registered at the General Post Office as a Newspaper.] PRICE ... 1s. BY FOREIGN POST 1s. 4d.

Aveling & Porter, Ltd., ROCHESTER. 1869

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E. J. Davis, M.I.Mech.E., Gas Engines Inspected, Tested and Reported upon. Over 25 years' experience. Tel.: Maryland 1736 & 1737. Wire: "Rapidising London." —Great Eastern Road, Stratford, E. 15. 1794

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THE GLASGOW ROLLING STOCK AND PLANT WORKS. Hurst, Nelson & Co., Ltd., Builders of RAILWAY CARRIAGES, WAGONS ELECTRIC CARS, and EVERY OTHER DESCRIPTION OF RAILWAY and TRAMWAY ROLLING STOCK. Makers of WHEELS and AXLES, RAILWAY PLANT, FORGINGS, SMITH WORK, IRON & BRASS CASTINGS. PRESSED STEEL WORK OF ALL KINDS. Od 3482 Reg. Office and Chief Works: Motherwell. London Office: 32, Great St. Helen's, Bishopsgate, E.C. 3.

Tank Locomotives. Specification and Workmanship equal to Main Line Locomotives. R. & W. HAWTHORN, LESLIE & CO. LTD., ENGINEERS, NEWCASTLE-ON-TYNE. 1864

Spencer-Hopwood & Kirke PATENT BOILERS. See page 73, May 2. 1994 Sole Makers: SPENCER BONECOURT, LTD., Parliament Mansions, Victoria St., London, S.W.

The Glasgow Railway Engineering Company, GOVAN, GLASGOW. LTD., London Office—12, Victoria Street, S.W. MANUFACTURERS OF RAILWAY CARRIAGE, WAGON & TRAMWAY WHEELS & AXLES. CARRIAGE & WAGON IRONWORK, also CAST-STEEL AXLE BOXES. 1943

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CRANES. All Types. GEORGE RUSSELL & CO., LTD., Motherwell. 1867 Telegrams:—"Cylinders," Birmingham.

Weldless-Steel Tubes for Water-tube Boilers, Superheaters, Heating, Hydraulic Work, Boring Rods, &c. TUBES LIMITED, BIRMINGHAM. O8179

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Campbells & Hunter, Ltd. SPECIALISTS IN Drillers & Boring Machinery for Engine Works and Boiler Shops. DOLPHIN FOUNDRY, LEEDS. 4547

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The Mitchell Conveyor and TRANSPORTER CO., LTD., CONTRACTING ENGINEERS. DESIGNERS and BUILDERS of all Classes of HANDLING MACHINERY. Atlantic House, 45-50, Holborn Viaduct, London, E.C. 1. Telegrams: "Miscontraco, Cent, London. Telephone: Holborn 3622. 1713

Dredging Plant— For ALLUVIAL GOLD, PLATINUM & TIN, HARBOUR, RIVER & CANAL.—Gravel Dredgers, SCREENS.—DREDGE BUCKETS & Parts, all sizes. ARTHUR R. BROWN, 54, New Broad Street, London, E.C.2. Telephone: London Wall 3418. 1814

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Regent Guillotine Shears and Power Presses FOR SHEET AND PLATE WORKING. THE REGENT SHEET METAL MACHINE TOOL CO., LTD., REGENT WORKS, WAKEFIELD. 2018

Iron and Steel Tubes and Fittings. Sole Licensees in Great Britain for the manufacture of "Armco" Rust and Corrosion Resisting Iron Tubes. 617

The Scottish Tube Co., Ltd., HEAD OFFICE: 54, Robertson Street, Glasgow. See Advertisement page 53.

Royles Limited, ENGINEERS, IRLAM, MANCHESTER. FEED WATER HEATERS, CALORIFIERS, EVAPORATORS, CONDENSERS, AIR HEATERS } ROW'S PATENTS. STEAM and GAS KETTLES. Merrill's Patent TWIN STRAINERS for Pump Suctions. SYPHONIA STEAM TRAPS, REDUCING VALVES High-class GUNMETAL STEAM FITTINGS. WATER SOFTENING and FILTERING. 5723

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STEWARTS AND LLOYDS, Ltd. GLASGOW BIRMINGHAM LONDON. See Advertisement, page 27. 1872

Electric Generating Plant for SALE.

Direct Current.

Two	26 Kw.	105 Volts.	"Howden-B.H.B."
Two	52 "	" "	"Brotherhood-Laurence Scott."
Two	100 "	440/500 "	Gerrett Semi-Portable.
One	120 "	110 "	"Bellis-Siemens."
One	150 "	220 "	"Howden-Lane, Dynamo."
Two	200 "	" "	"W. H. ALLEN."
Two	200 "	" "	"Bellis-Siemens."
One	240 "	440/500 "	"Bellis-Phœnix Dynamo."
One	375 "	250 "	"Allen-Westinghouse."
One	400 "	240 "	"Howden-Siemens."
One	500 "	220 "	"Howden-B.T.H."
One	500 "	230 "	"Bellis-B.T.H."
One	500 "	500 "	Metropolitan Vickers Turbo.
One	600 "	500 "	"Bellis-Mather & Platt."
One	750 "	220 "	"Parsons-Crompton" Geared Turbo.
One	1250 "	250 "	"Bellis" Turbo.

Alternating Current, 3-Phase, 50 Periods.

One	400 Kw.	500/550 Volts.	"Howden-G.E.C."
One	750 "	" "	"Metropolitan Vickers."
One	850 "	" "	"Fraser & Chalmers."
Two	1000 "	" "	"Metropolitan-Vickers."
One	1000 "	3300 "	"B.T.H."
Two	1000 "	" "	"Metropolitan-Vickers."
One	2000 "	500/550 "	" "
One	3000 "	6600 "	"B.T.H." "

All above are modern, and condensing plant is available in nearly all cases. We can also offer several Suction Gas and Diesel Sets, Babcock Boilers up to 30,000 lbs. per hour, and a very large number of motors, generators, Motor-generators, rotary converters, etc. Enquiries Invited. THE PHŒNIX ELECTRICAL COMPANY, LTD., 17, OSWALD STREET GLASGOW. 823

ON ADMIRALTY LIST.

John Kirkaldy, Ltd., London Office: 101, LEADENHALL ST., E.C.3. Works: BURNT MILL, near HARLOW, ESSEX Makers of Evaporating and Distilling Plants. Refrigerating and Ice-making Machinery. Feed Water Heaters. Evaporators. Fresh Water Distillers. Main Feed Pumps. Combined Circulating and Air Pumps. Auxiliary Surface Condensers, &c., &c. 1586

For Sale.—Floating Electric POWER STATION, 1000 Kw., with Parsons Geared Turbines, and Generators D.C. 110/575 volts and A.C. 220/7600 volts. Steam from 6 Oil-fired Boilers. Installed on Barge 165 ft. by 25½ ft. with workshop and storeroom. Also Fuel Oil Steel Barge of 80 tons capacity, and 500 Kw. Vickers Rotary Converter and Transformer converting A.C. into 440 volts D.C. For further particulars apply:— SECRETARY, FORTH SHIPBUILDING & ENGINEERING CO. (1921), LTD., 29, Great St. Helen's, E.C.3. 1823

Penningtons, University TUTORS, 324, Oxford Road, Manchester. Estab. 1876. Enrol now for I.C.E. and I.M.E. Postal Courses. 100 per cent. passes last Exams. Reinforced Concrete—a new comprehensive course under expert engineer, £3 3s. Write for particulars. 1711

For Sale, Motor-Driven Air COMPRESSOR, by Belliss & Morcom. 1000 cubic ft. per min. 100 lbs. pressure, with 500 volt D.C. motor.—THE PHŒNIX ELECTRICAL CO., LTD., 17, Oswald Street, Glasgow. D 321

YARROW & CO. (1922), LTD., GLASGOW. LAND AND MARINE YARROW BOILERS. 1553

John Bellamy Limited, MILLWALL, LONDON, E. GENERAL CONSTRUCTIONAL ENGINEERS. 1316

Boilers, Tanks & Mooring Buoys STILLS, PETROL TANKS, AIR RECEIVERS, STEEL CHIMNEYS, RIVETTED STEAM and VENTILATING PIPES, HOPPERS, SPECIAL WORK, REPAIRS OF ALL KINDS.

Head, Wrightson & Co., LIMITED. See Advertisement page 61, May 2. 2402

Matthew Paul & Co., Ltd., LEVENFORD WORKS, Dumbarton. 1483 See Full Page Advt., page 40, April 25.

Taylor & Challen Presses For Production of SHEET METAL WORK, COINAGE, CARTRIDGES AND GUNPOWDER. Foundry, Works and Showrooms: BIRMINGHAM. See Advert., page 98, April 25 8195

Cement.—Maxted & Knott, LTD., Consulting Cement Engineers, ADVISE GENERALLY on proposed Cement Schemes FOR ENGLAND AND ABROAD. ADVICE ONLY. Highest References. Established 1890. Address, BURNETT AVENUE, HULL. Cablegrams: "Energy, Hull." 1828

Railway Switches and Crossings. T. SUMMERSON & SONS, LIMITED, DARLINGTON. 2006

Plenty and Son, LIMITED, STATIONARY, STEAM AND MARINE ENGINEERS. NEWBURY, ENGLAND. 1831

WAYGOOD OTIS LIFTS 2130 54 & 55, FETTER LANE, LONDON, E.C.4. 62 & 63, LIONEL STREET, BIRMINGHAM, and Principal Provincial Cities and Abroad.

Diesel Engines, 300, 530, 800, 1200 and 1750 B.HP., M.A.N., with or without dynamos; condition as new. About one-third market price; seen London. For all spares above sizes in stock. HICK DIESEL OIL ENGINES, LTD., 70, Queen Street, E.C. 4. 2042

Haul Paying Load— Not Dead Weight. Reduce Weight with Aluminium. Data from British Aluminium Co., Ltd., 10a, Queen Victoria St., London. 2017

The Manchester Steam Users' ASSOCIATION.

For the prevention of Steam Boiler Explosions and for the attainment of Economy in the Application of Steam. 9, MOUNT STREET, MANCHESTER.

Chief Engineer: C. E. STROMEYER, M.I.C.E.

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COURSES IN MECHANICAL ENGINEERING.

Professor F. C. LEA, D.Sc., M.Inst.C.E., M.I.Mech.E., Professor of Mechanical Engineering.

Degree, Associateship, and Works Pupils' Courses.

Applications are also invited from those desiring to do Research Work in Engineering.

Full particulars may be obtained from PROFESSOR LEA, Department of Applied Science, St. George's Square, Sheffield,

W. M. GIBBONS, Registrar. D 631

Battersea Polytechnic, London, S.W.11.

Short Summer Courses of eight lectures will be held in the following subjects, commencing May 12th :—

Strength of Materials,
Theory of Structures,
Theory of Machines,
Hydraulics,
Heat Engines,
Machine Drawing and Design.

The above are revision courses suitable for the Final B.Sc., Hug., the A.M.I.C.E., or the A.M.I.M.E. Examination.

Also a special Course of lectures with practical testing, on Petrol Engines.

For further particulars apply to the PRINCIPAL. D 623

Correspondence Courses for

Inst.Civil Engrs., Inst.Mech.E., London Univ (Matric., Inter., B.Sc.), and All ENGINEERING EXAMINATIONS personally conducted by Mr. TREVOR W. PHILLIPS, B.Sc. (Honours), Assoc. M.Inst.C.E., M.R.S.I., F.R.S.A., etc. Also Day Tuition in Office. Excellent results at all Exams. Courses may commence at any time, and all Students receive individual tuition.—For full particulars apply to S/11, TRAFFORD CHAMBERS, 58, SOUTH JOHN STREET, LIVERPOOL. 1993

Engineering Salesmanship

and SALES MANAGEMENT.—Write for brochure describing our special Course of Training for posts of unlimited scope in this lucrative field.—DIRECTOR, Institute of Engineering Salesmanship, 333, Oxford Road, Manchester. 2108

TENDERS.

LODGE HILL, NEAR CHATHAM.

Tenders are Invited for the PURCHASE and REMOVAL of the undermentioned TIMBER FRAMED HUTS, now at Chattenden Farm, Lodge Hill, and of approximate floor measurements as follows :—

4 No. 65 ft. by 17 ft.
7 No. 61 ft. by 21 ft.
1 No. 50 ft. by 16 ft.

Tenders are to be delivered not later than Noon on 16th May, 1924, to SUPERINTENDING CIVIL ENGINEER, H.M. Dockyard, Chatham, from whom full particulars and Forms of Tender may be obtained. D 649

THE DUBLIN PORT AND DOCKS BOARD is prepared to receive

Tenders for Two Pairs of CAST STEEL TRAMWAY TYPE RAIL SWITCHES with Manganese Tongues.

Particulars and Drawing may be obtained on application to the Engineer's Office, East Wall, Dublin, between Ten a.m. and Four p.m.

Sealed Tenders, endorsed on the outside "Tender for Points," should be delivered to THE SECRETARY, Port and Docks Office, Westmoreland Street, on or before Tuesday, 20th May, 1924.

The Board does not bind itself to accept the lowest or any Tender.

Port and Docks Office,
5th May, 1924. D 692

THE DUBLIN PORT AND DOCKS BOARD is prepared to receive

Tenders for About 1750 Feet

of Mersey Dock Section STEEL TRAMWAY RAILS, 126 lbs. per yard, complete with Fishplates, Bolts and Nuts.

Drawing may be obtained on application to the Engineer's Office, East Wall, Dublin, between Ten a.m. and Four p.m.

Sealed Tenders, endorsed on the outside "Tenders for Rails," should be delivered to THE SECRETARY Port and Docks Office, Westmoreland Street, on, or before Tuesday, 20th May, 1924.

The Board does not bind itself to accept the lowest or any Tender,

Port and Docks Office,
5th May, 1924. D 691

GREAT NORTHERN RAILWAY (IRELAND).

TO BUILDING CONTRACTORS.

The Directors are prepared to receive

Tenders for Erection of an ENGINE SHED, in Reinforced Concrete, at Clones Station.

The Drawings and Specification may be inspected at the Engineer's Offices, Dublin and Belfast, and copies of same, together with Bill of Quantities and Form of Tender, may be obtained from the Undersigned on payment of Two Guineas, which will be refunded on receipt of a *bona fide* Tender and return of the Drawings.

Tenders made out on the Forms supplied by the Company, should be delivered under sealed cover, endorsed "Tender for Engine Shed," not later than Ten a.m. on Friday, 23rd May, 1924.

The Directors do not bind themselves to accept the lowest or any Tender,

J. B. STEPHENS, Secretary.

Amiens Street Station,
Dublin, 1st May, 1924. D 670

CITY OF LIVERPOOL.

TRAMWAY MATERIAL.

The Corporation are prepared to receive

Tenders for the Supply and DELIVERY of various classes of TRAMWAY MATERIAL, as under :—

SCHEDULE No. 1. Steel Tramway Rails and Fishplates.
SCHEDULE No. 2. Steel Fishbolts.
SCHEDULE No. 3. Steel Trebars.
SCHEDULE No 4. Copper Bonds.

Firms are required to state clearly, when making application for the necessary Tender Forms, the name and number of the Schedule for which they desire to be furnished with Tender Form.

Duplicate Forms of Tender for record purposes will NOT be supplied.

Tender Forms will be forwarded UPON RECEIPT OF APPLICATION IN WRITING to :—

THE CITY ENGINEER,
Municipal Buildings, Dale Street, Liverpool.

Tenders must be sealed and enclosed in the official envelopes provided, endorsed in accordance with the instructions given on the Form of Tender, and FORWARDED THROUGH THE POST, addressed to :—

"The Town Clerk, Municipal Buildings, Liverpool."

LATEST TIME AND DATE FOR RECEIPT OF TENDERS :—

TEN O'CLOCK A.M., ON FRIDAY, THE 23rd, MAY, 1924.

WALTER MOON, Town Clerk.

1st May, 1924. D 690

SITTINGBOURNE URBAN DISTRICT COUNCIL.

PROPOSED RE-ARRANGEMENT OF SEWERAGE WORKS PLANT.

THE SITTINGBOURNE URBAN DISTRICT COUNCIL are prepared to receive

Tenders for the Supply and ERECTION of PLANT for their Sewage Disposal Works, Sittingbourne, as follows :—

TWO HORIZONTAL OR VERTICAL FOUR CYCLE CRUDE OIL ENGINES. Each 50 B.H.P., TO START WITHOUT USE OF EXTERNAL HEAT, TOGETHER WITH AIR COMPRESSORS; ALSO AUXILIARY AND TEMPORARY PLANT, Etc.

Preliminary Plans may be inspected, and specification and forms of Tender obtained on and after 12th May, 1924, on application at the Offices of the Council's Engineer, Mr. T. W. ELLIS, 110, Victoria Street, Westminster, London, S.W.; or at the Office of the Surveyor to the Council, Mr. M. W. LASHMAR, Town Hall, Sittingbourne.

For each specification a deposit of £3 3 will be required, which sum will be returned to the Tenderer, provided that he shall have sent in a *bona fide* Tender, based on the specification, etc., and which has not been withdrawn prior to the definite acceptance of a Tender by the Council.

Duplicate copies of the Specification will be supplied at a charge of 10/6 each (not returnable).

The copy of the Specification supplied is to be returned intact with Tender Form, filled up and signed, addressed to the undersigned, and to be received by him before Noon on the 2nd June, 1924, enclosed in a sealed packet marked on the outside "Tender for Sewage Disposal Plant."

The lowest or any Tender will not necessarily be accepted, nor will any expense in connection with Tendering be defrayed.

G. H. POTTER, Clerk to the Council.

76, High Street, Sittingbourne. D 709

METROPOLITAN WATER BOARD.

MAIN, KEMPTON TO CRICKLEWOOD. TENDERS FOR SECTION No. 2.—LAYING 48 in. CAST IRON MAIN, and Contingent Works from Greenford to Cricklewood and the LAYING of 27 in. CAST IRON PIPES from near Hanger Lane to Ealing.

The Metropolitan Water Board Invite

Tenders for the Laying and JOINTING of about 8445 yards of 48 in. diameter CAST IRON WATER MAIN, principally through fields, and also the laying of about 1620 yards of 52 in. STEEL PIPES, mainly in subways: from Windmill Lane north of the Board's existing Valve House in the Parish of Greenford, to the Board's Works at Cricklewood, in the Parish of Willesden, together with about 1447 yards of 27 in. diameter CAST IRON MAIN branching from the 48 in. diameter main near Hanger Lane in the Parish of Wembley and extending to the neighbourhood of the Board's Fox Reservoir in the Parish of Ealing, all in the County of Middlesex.

Drawings, Conditions of Contract and Specifications may be inspected without payment of a fee at the Offices of the Board, Chief Engineer's Department (Room 201) on and after 14th May, 1924.

Form of Tender, Conditions of Contract, Specification, Bills of Quantities and Schedules of Prices, together with drawings and a spare copy of the Bills of Quantities and Schedules of Prices, may be obtained on and after 19th May, 1924, from Mr. HENRY H. SYCLOSE, M.Inst.C.E., the Chief Engineer, on production of an official receipt for the sum of £20, which sum must be deposited with the Accountant to the Board, and will be returned on receipt of a *bona fide* tender, accompanied by all the above-named documents and drawings (with the exception of the spare copy of Bills of Quantities and Schedules of Prices, which may be retained by the Tenderer). Such payments and applications must be made between the hours of Ten a.m. and 4.30 p.m. (Saturdays Ten a.m. and 12 Noon). Cheques must be made payable to the "Metropolitan Water Board" and not to individuals.

Tenders enclosed in sealed envelopes, addressed to "The Clerk of the Board, Metropolitan Water Board, New River Head, Clerkenwell, E.C.1," and endorsed "Tender for Main, Kempton to Cricklewood, Section No. 2," must be delivered at the Offices of the Board (Room 129) not later than Ten a.m. on Thursday, 5th June, 1924.

The Board do not bind themselves to accept the lowest or any Tender.

G. F. STRINGER, Clerk of the Board.

Offices of the Board,
New River Head,
Clerkenwell, E.C.1.
6th May, 1924. D 714

BENGAL-NAGPUR RAILWAY COMPANY LIMITED.

The Directors are prepared to receive

Tenders for :—

(A) MILD STEEL PLATES AND FLATS.
(B) MILD STEEL ANGLES.

Specifications and Forms of Tender can be obtained at the Company's Offices, 132, Gresham House, Old Broad Street, E.C. 2, on or after 7th May, 1924.

A fee of 20/- will be charged for Specification (A), and 10/- for (B), which are NOT returnable.

Tenders must be submitted not later than NOON, on Wednesday, 21st May, 1924.

The Directors do not bind themselves to accept the lowest or any Tender, and reserve to themselves the right of reducing or dividing the orders.

By Order of the Board,
R. V. VOLKERS, Secretary.

D 704

ROYAL BURGH OF KIRKCALDY. ELECTRICITY WORKS, VICTORIA ROAD.

The Provost, Magistrates and Council invite

Tenders for the Following Work :—

SPECIFICATION No 38. CABLES & ROADWORK.

A copy of the Specification and Drawings can be seen at and obtained from the offices of Messrs. KENNEDY & DONKIN, 8, Broadway, Westminster, S.W.1, upon payment of a deposit of £2 2s. (cheque, postal or money order). An additional copy of the Specification can be obtained upon payment of a deposit of £1 1s. These deposits will be returned after the receipt of a *bona fide* Tender, and on the return of the Specification.

Tenders on the prescribed Form, enclosed in sealed envelopes, and addressed on the outside :—

"Electricity Supply, Tender to Specification No. 38," must be delivered at the office of the undersigned not later than Ten a.m., on Monday 26th May, 1924.

The Council do not bind themselves to accept the lowest or any Tender.

W. L. MACINDOE, Esq., Town Clerk's Office, Kirkcaldy.

May, 1924. D 705

ABERDEEN CORPORATION WATER WORKS.

EXTENSIONS 1920.

Contract No. 19.—PIPELAYING.

The Town Council of Aberdeen are prepared to receive

Tenders from Competent

Persons willing to enter into a Contract for the TRANSPORTING, LAYING and JOINTING of about 5500 lineal yards of CAST IRON PIPES, from 30 in. to 13 in. in diameter, and Ancillary Works in and near the City of Aberdeen.

The Drawings may be inspected and Specification, Schedule of Quantities, and Form of Tender obtained on and after 2nd May, 1924, on application at the Water Engineer's Office, 41½, Union Street, Aberdeen. Early application is desirable, and no Specification will be given out after 12th May.

For each Specification a deposit of Five Pounds Sterling will be required, which sum will, after a Tender has been accepted, be returned to the Tenderer, provided that he shall have sent in a *bona fide* Tender, based on the Drawings, Specification, and Schedule of Quantities provided, with the Schedule of Quantities fully priced out in detail, and shall not have withdrawn the same.

The employment of labour shall be in accordance with the conditions of the Unemployment Grants Committee.

Tenders on the forms prescribed, and enclosed in securely sealed envelopes, endorsed "Tender for PIPELAYING," are to be addressed to the undersigned. No Tender delivered after Twelve Noon, on 19th May, 1924, will be considered.

The Town Council do not bind themselves to accept the lowest or any Tender.

GEORGE MITCHELL, M.Inst.C.E., F.C.S. Water Engineer's Office,
41½, Union Street, Aberdeen,
29th April, 1924. D 648

TO ENGINEERS AND SHIPBUILDERS.

Tenders are Invited for the CONSTRUCTION and DELIVERY afloat in the RIVER THAMES of a SINGLE SCREW RIVER TUG of the following dimensions :—Length overall 68 ft. 9 in. Length B.P. 64 ft. 0 in. Breadth moulded 14 ft. 9 in. Depth moulded 8 ft. 0 in. Draft as limited to 6 ft. 6 in. with boiler and condenser full and four tons of coal on board. To be built of steel to design and specification, to be submitted for approval. The following principal scantlings :—Frames 3 in. by 2½ in. by ¾ in. spaced 16 in. for ⅓rds length, amidships, and 15 in. at ends. Reverse frames 2½ in. by 2½ in. by 5/16 in. to upper turn of bilge and deck alternately. Bulkhead frames 4 in. by 3 in. by 7/16 in. Plating sheerstrake 8/20 in. Keelplate 42 in. by 8/20 in. with outside doubling plate 18 in. by 6/20 in. Remainder 6/20 in. Floors 10 in. by 8/20 in. Centre keelson double angles 3 in. by 3 in. by ½ in., intercostal plates ½ in. Keel angles 3 in. by 3 in. by ½ in. Side Keelsons double 3 in. by 3 in. by ½ in. Deck chequered Admiralty pattern, ½ in. thick on plate. Bulwarks 20 in. high to tumble home 12 in. all round and to be well stayed and doubled round stern bulwarks with 6/20 in. plating. Main rail 4 in. by 2½ in. by 5/16 in. bulb angle. Rubbing band 5 in. wide double rivetted. MACHINERY.—Engines, Compound Surface Condensing not less than 12 in. and 24 in. by 18 in. stroke, guaranteed to develope 230 I.HP. at 160 r.p.m. Cast Steel Propeller 5 ft. 9 in. dia. and about 7 ft. pitch, four bladed and having ample surface. Boiler, steel, about 9 ft. dia. with heating surface about 950 sq. ft., grate area 23 sq. ft., with Dome. Two furnaces and separate combustion chambers, with all mountings for a working pressure of 160 lbs. per sq. in. Funnel to lower on a V joint and Cast Iron balance weights. Pumps, general service pump, Duplex type, with all requisite piping and connections. The whole to be completed with usual outfit for river work, and of first-class workmanship and material. Hull and machinery to be at least equal in all respects to Board of Trade and/or Lloyd's Rules, with certificates furnished for same. TENDERS to be undermentioned, who do not bind themselves to accept the lowest or any Tender.

TOUGH & HENDERSON, Tug Owners,
53, Upper Ground Street, Blackfriars,
London, S.E.1. D 697

The Director-General, INDIA STORE DEPARTMENT, Branch No. 16, Belvedere Road, Lambeth, S.E. 1, REQUIRES :—

SLUICE GATES, 60 feet by 15 feet, and Gear No. 24.

Tenders due on the 27th May, 1924.

Tender forms obtainable from above. D 715

THE GREAT INDIAN PENINSULA RAILWAY COMPANY, 48, COPTHALL AVENUE, LONDON, E.C.2, invite

Tenders for :—

1. BELLS, BIB COCKS, &c. ... ... Fee 5/-
2. GALVANISED SHEETS ... ... " 5/-
3. METALS ... ... " 5/-
4. BRASS SHEETS & COPPER TUBES " 5/-

Tenders are due by Eleven a.m. on 20th May, 1924. Tender forms obtainable at above address. Fees not returnable. D 717

BILLINGE URBAN DISTRICT.

The Urban District Council of Billinge invite

Tenders for about 70 tons of CAST IRON PIPES, with Bends, Junctions, &c., Valves and Hydrants Particulars, Specification and Form of Tender may be had on application to Surveyor, Council Offices, Billinge, Near Wigan. Tenders, sealed and endorsed "Cast Iron Pipes," to be addressed to the undersigned and delivered not later than the 13th May, 1924.

ALFRED DARLINGTON, Clerk.

Council Offices, Billinge,
30th April, 1924. D 673

THE SOUTH INDIAN RAILWAY COMPANY LIMITED, are prepared to receive

Tenders for the Supply of :—

LAMINATED SPRINGS AND SPRING STEEL.

Specifications and Forms of Tender will be available at the Company's Offices, 91, Petty France, Westminster, S.W.1.

Tenders, addressed to the Chairman and Directors of the South Indian Railway Company, Limited, marked :—"Tender for Laminated Springs and Spring Steel," must be left with the undersigned not later than Twelve Noon on Friday, the 23rd May, 1924.

The Directors do not bind themselves to accept the lowest or any Tender.

A charge, which will not be returned, will be made of 5s. for each copy of the Specification.

Copies of the drawings may be obtained at the Offices of Messrs. ROBERT WHITE & PARTNERS, Consulting Engineers to the Company, 3, Victoria Street, Westminster, S.W.1.

A. MUIRHEAD, Managing Director.

91, Petty France, S.W.1.
6th May, 1924. D 716

PORT OF BRISTOL.

NEW ELECTRIC CRANES, BRISTOL CITY DOCKS.

The Docks Committee are prepared to receive

Tenders for the Construction of THREE 2-ton MOVABLE ELECTRIC JIB CRANES, and the ERECTION of the same on the roof of Shed "U" (now in course of reconstruction), Canon's Marsh, Bristol City Docks.

On and after Tuesday, the 13th day of May, 1924, copies of the General Conditions, Specification, Schedule of Prices and Contract Drawing can be obtained from the undersigned on production of a receipt showing that a deposit of £5 has been paid to the Bristol Docks Committee (TO WHOM ALL CHEQUES MUST BE MADE PAYABLE), 19, Queen Square, Bristol. The deposit of £5 will be returned hereafter to all *bona fide* Tenderers.

Tenders must be enclosed in a sealed envelope, endorsed "Tender for Three Electric Cranes," and addressed to the General Manager and Secretary of the Docks Committee, 19, Queen Square, Bristol, and must be delivered to him, accompanied by all the prescribed documents and drawings, before Ten a.m. on Monday, the 9th day of June, 1924.

The Docks Committee do not bind themselves to accept the lowest or any Tender.

THOMAS A. PEACE, Engineer, Port of Bristol.

Chief Engineer's Office,
Avonmouth Docks.
9th May, 1924. D 699

APPOINTMENTS OPEN.

THE UNIVERSITY OF MANCHESTER.

Applications are Invited for the POST of ASSISTANT LECTURER in ENGINEERING. Stipend £300 per annum.

Candidates should have some Civil Engineering experience and be able to give assistance in the Surveying Field courses.

Applications should be sent to the Internal Registrar not later than 21st June.—Further particulars may be obtained on application to the INTERNAL REGISTRAR. D 595

STAFFORDSHIRE EDUCATION COMMITTEE. COUNTY TECHNICAL COLLEGE, WEDNESBURY.

An Assistant Lecturer is REQUIRED to begin work in September. Salary will be paid according to the Burnham (Technical) Scale, less the 5 per cent. abatement for the current financial year. Candidates must be qualified to give class-room and laboratory instruction in Physics and Mathematics. Works and Drawing Office experience in Electrical Engineering is desirable. Further particulars and forms of application, which must be returned not later than May 21st, 1924, may be obtained from the undersigned on receipt of a stamped addressed envelope.

GRAHAM BALFOUR, Director of Education.

County Education Offices, Stafford, 3rd May, 1924. D 685

Engineering Journal.—ASSISTANT EDITOR WANTED. Preference given to man with past experience in similar position, capable of writing on new MACHINERY and PLANT and MODERN PRODUCTION METHODS.—Address (in confidence), stating qualifications, salary, etc., D 671, Offices of ENGINEERING.

(To face Page 594.)

WADDAMANA POWER STATION OF THE GREAT LAKE HYDRO-ELECTRIC SCHEME, TASMANIA.

MR. J. H. BUTTERS, M.I.E.E., CHIEF ENGINEER AND GENERAL MANAGER, HYDRO-ELECTRIC DEPARTMENT, TASMANIA, ENGINEER.

(*For Description, see Page* 595.)

FIG. 59. EXTERIOR OF THE POWER STATION.

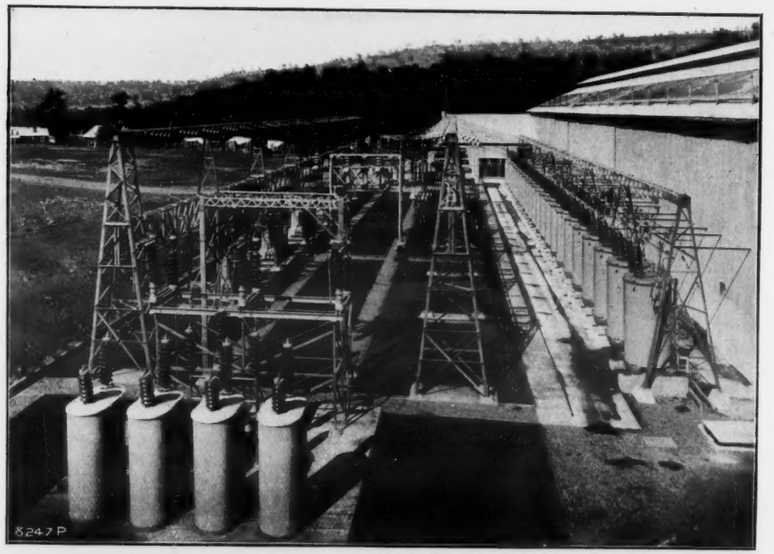


FIG. 60. TRANSFORMERS AND HIGH TENSION SWITCH GEAR.

FIG. 61. INTERIOR, SHOWING FIRST UNITS INSTALLED, IN FOREGROUND.

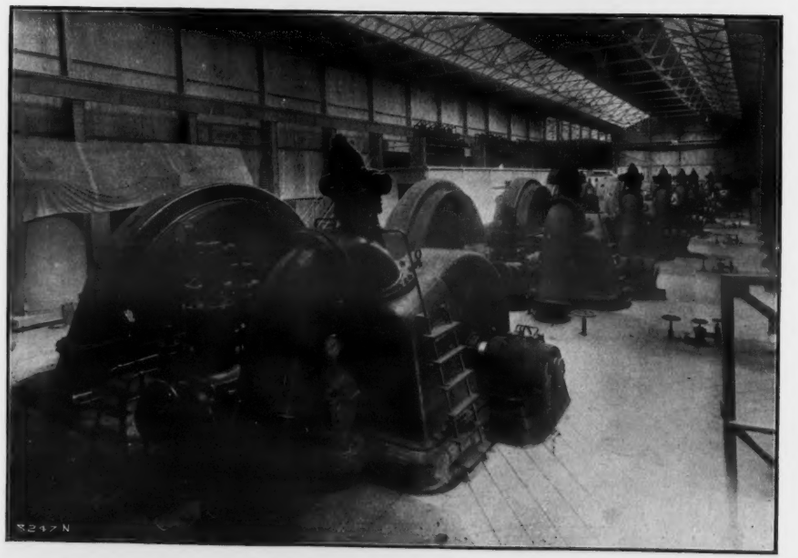


FIG. 62. INTERIOR, SHOWING THE LATER UNITS INSTALLED, IN FOREGROUND.

WADDAMANA POWER STATION OF THE GREAT LAKE HYDRO-ELECTRIC SCHEME, TASMANIA.

MR. J. H. BUTTERS, M.I.E.E., CHIEF ENGINEER AND GENERAL MANAGER, HYDRO-ELECTRIC DEPARTMENT, TASMANIA, ENGINEER.

(*For Description, see Page 595.*)

Fig. 63.

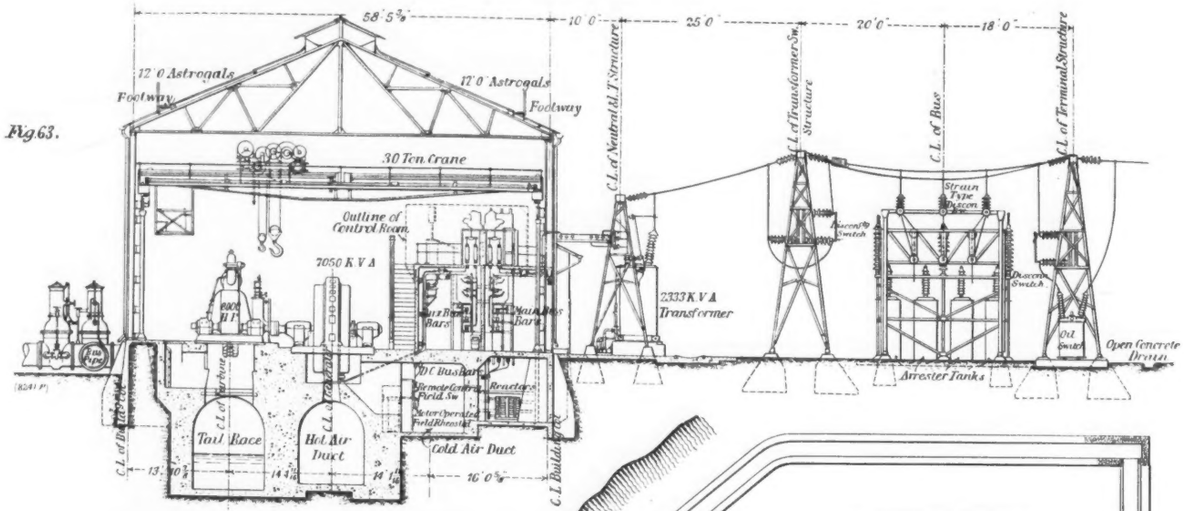
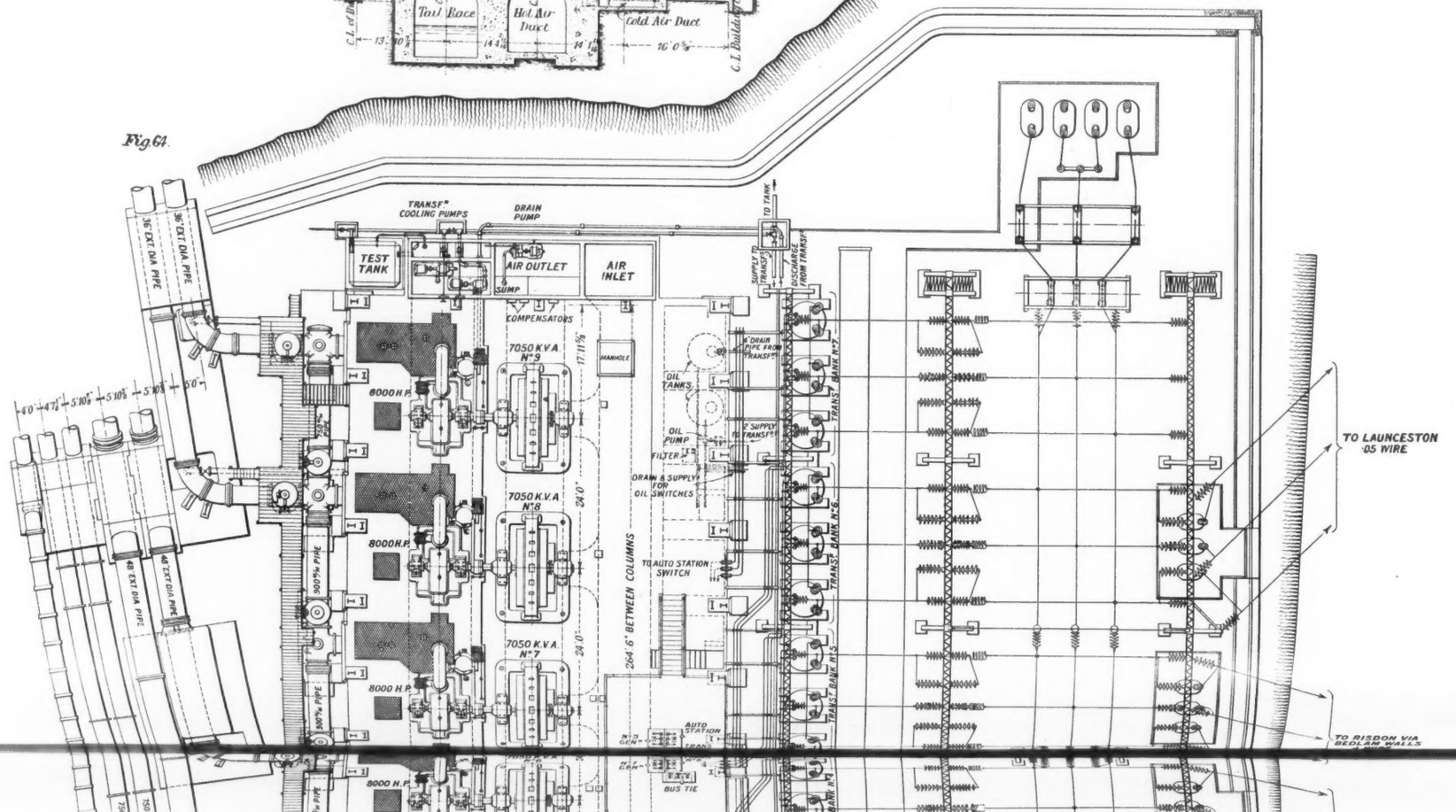
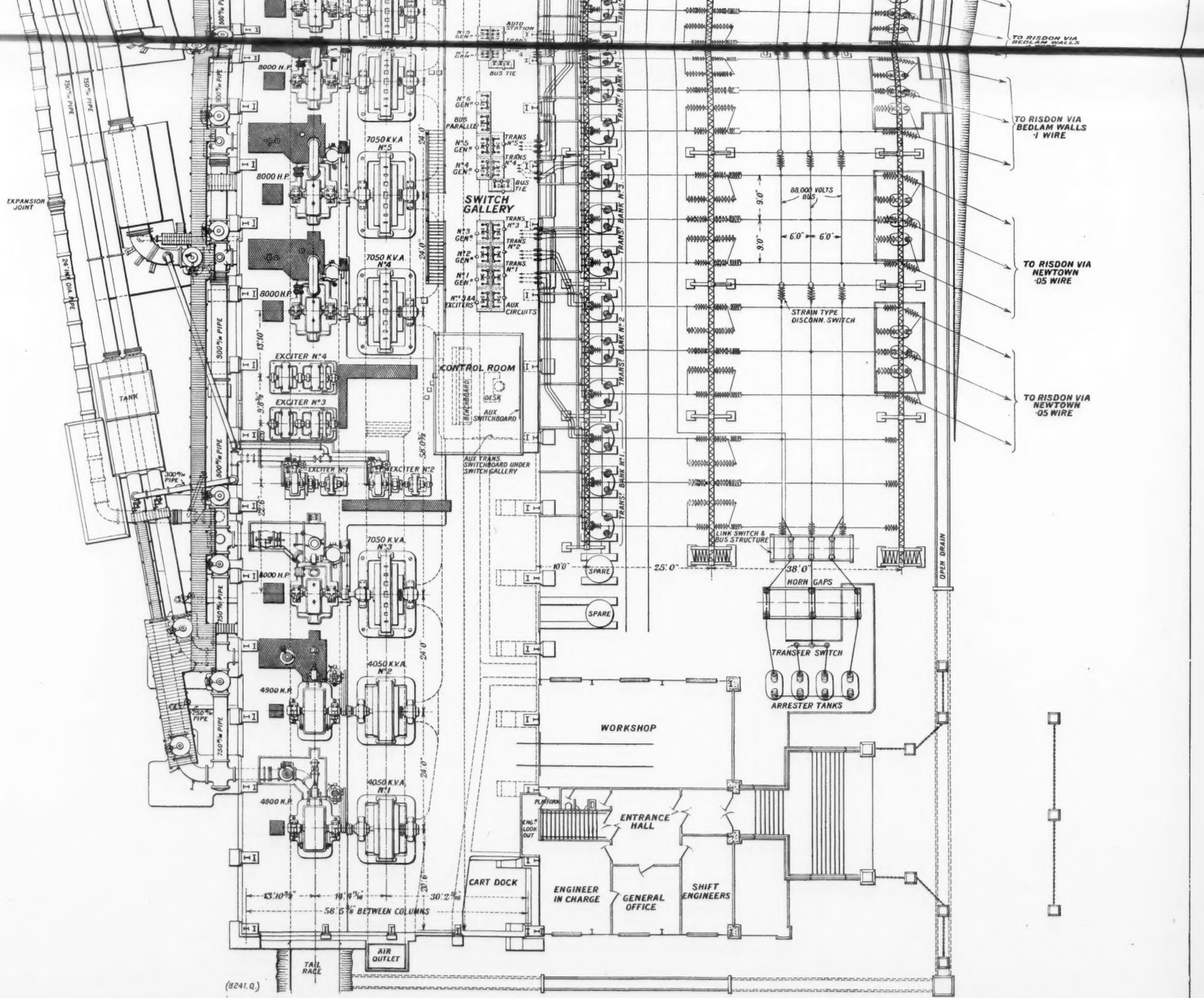


Fig. 64.

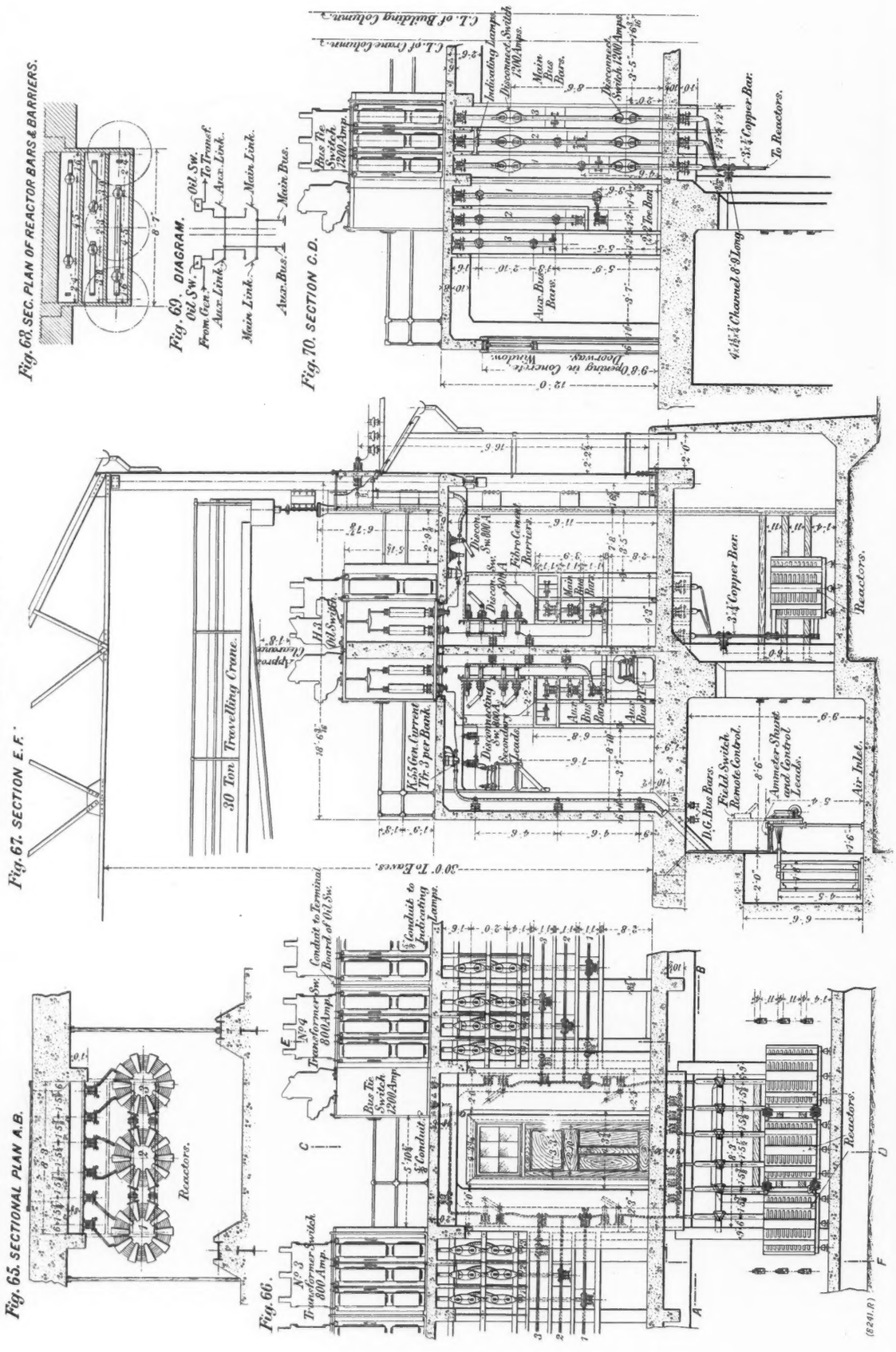



TO RISDON VIA BEDLAM WALLS
TO RISDON VIA BEDLAM WALLS -1 WIRE
TO RISDON VIA NEWTOWN -05 WIRE
TO RISDON VIA NEWTOWN -05 WIRE
88,000 VOLTS BUS
STRAIN TYPE DISCONN. SWITCH
LINK SWITCH & BUS STRUCTURE
HORN GAPS
TRANSFER SWITCH
ARRESTER TANKS
OPEN DRAIN
SWITCH GALLERY
CONTROL ROOM
AUX SWITCHBOARD
AUX TRANS SWITCHBOARD UNDER SWITCH GALLERY
EXCITER N°4
EXCITER N°3
EXCITER N°1
EXCITER N°2
7050 K.V.A N°5
7050 K.V.A N°4
7050 K.V.A N°3
4050 K.V.A N°2
4050 K.V.A N°1
8000 H.P.
4900 H.P.
TANK
EXPANSION JOINT
24" INT. DIA. PIPE
300 m/m PIPE
350 m/m PIPE
750 m/m PIPE
SPARE
WORKSHOP
ENTRANCE HALL
ENGINEER IN CHARGE
GENERAL OFFICE
SHIFT ENGINEERS
CART DOCK
AIR OUTLET
TAIL RACE
58'6 5/8" BETWEEN COLUMNS
(8241.Q.)

SWITCH GALLERY OF THE WADDAMANA POWER STATION OF THE GREAT LAKE HYDRO-ELECTRIC SCHEME, TASMANIA.

MR. J. H. BUTTERS, M.I.E.E., CHIEF ENGINEER AND GENERAL MANAGER, HYDRO-ELECTRIC DEPARTMENT, TASMANIA, ENGINEER.

(For Description, see Page 595.)



(To face Page 595.)

THE GREAT LAKE HYDRO-ELECTRIC SCHEME, TASMANIA.

(*Continued from page* 452.)

THE Waddamana power station supplied with hydraulic energy from the Great Lake, is illustrated on Plates LIX to LXI. An exterior and two interior views of it are given in Figs. 59, 61 and 62, Plate LIX, while Fig. 60 also on that Plate shows the outdoor transformers and high tension switch gear. The power house is a simple steel frame building, covered with galvanised corrugated iron, and is supported on concrete foundations. The foundations, which are almost entirely below the original ground level, consist of blocks and piers of mass concrete under the machines and building columns, connected by reinforced concrete slabs or arches over the intervening spaces. Three tunnels, to be seen in Fig. 63, run the full length of the building, one forming the tail race under the Pelton wheels and the other two forming the inlet and outlet air ducts. The passages connecting the air ducts to the generators, and all necessary manholes and inspection openings are formed in the concrete blocks comprising the foundations of the various machines. All cables are enclosed in fibre ducts embedded in the concrete floor.

The turbine room, Fig. 64, Plate LX, is 264 ft. long by 58 ft. wide. An electric crane of 30 tons capacity runs the full length of the building. From the bus pipe, nine branches lead through the western wall to the nine turbines, each branch being provided with a control valve. As originally built the room contained two 4,900 h.p., 375 r.p.m. Boving Pelton wheels, each connected to two British Westinghouse alternators of 4,050 k.v.a. each. Two 180 h.p. turbines, running at 700 r.p.m., and each connected to a 120 kw. D.C. generator, were installed for exitation, and are supplied by separate 8 in. diameter pipes. Provision was also made for a third unit, installed in 1918, comprising one 8,000 h.p. Boving turbine, connected to an alternator of 7,050 k.v.a., manufactured by the General Electric Company, U.S.A. These units are shown at the bottom of the plan, Fig. 64. The point where the extension of the power house began will be recognised in Fig. 64. The additions included six more units similar to No. 3. All the main turbines are of the Pelton wheel type running at 375 r.p.m. The 4,900 h.p. wheels have one nozzle and the larger ones two nozzles, from which the water issues at a velocity of 250 ft. per second. A governor of the oil pressure type, driven by a belt from the main shaft, controls a needle valve and deflector for each machine. The needle, which can also be controlled by hand, is made of bronze in the 4,900 h.p. and of steel in the 8,000 h.p. turbines; all the nozzles are of cast steel. The buckets are made of cast steel, ground and polished. Each wheel revolves in two large white metal-lined bearings, lubricated with oil rings, the oil being cooled by circulating through a pipe which passes along the wheel pit. All valves on the bus pipe and turbine inlets are provided with a by-pass to equalise the pressure on either side before operating them. The alternators are of the revolving field totally enclosed type, and generate three-phase current at a pressure of 6,600 volts and a frequency of 50 cycles. Fan vanes bolted to the rotor draw air from the cold air duct and discharge it either into a hot air duct or, if required, into the building for heating purposes. The bearings are ring lubricated and water-cooled. Both ends of all windings are brought out and pass through current transformers and the neutral point is then earthed through a disconnecting switch. The machines are protected by out-of-balance relays.

In addition to the turbine-driven exciters there have also been installed two motor generator sets manufactured by Bruce Peebles and Company. These have 6,600 volt, three-phase wound rotor induction motors running at 580 r.p.m. and driving 110/120-volt D.C. generators. These machines supply power to the overhead crane and for battery charging in addition to supplying exciting current. Of the two views of the interior, Figs. 61 and 62, the former shows the original units in the foreground and the latter the units of the extension. The control room and switch gallery can be seen in the background. The latter occupy a portion of the eastern side of the turbine room, the switch gallery being of reinforced concrete, and having an upper and lower floor. Details of the switch gallery are given in Figs. 65 to 70, Plate LXI. The lower floor, on a level with the turbine floor, accommodates a set of main and auxiliary bus bars, each bar being contained in a separate concrete compartment, running the length of the gallery, and also the necessary current and potential transformers for operating the instruments in the control room. Link switches are provided by means of which any generator or bank of transformers can be connected to either set of bus bars. On the upper floor of the gallery are placed twenty-one General Electric Company, U.S.A., remote controlled 6,600-volt oil switches. Each of the nine generators and each bank of transformers is connected to the bus bars through one of the oil switches. A diagram of connections is given in Fig. 69. Two oil switches serve to isolate the main bus bars into three sections, three generators and two or three banks of transformers being connected to each section, Fig. 64. By means of link switches these two oil switches can be isolated, and an alternative connection between the sections of the main bus bar made through reactors (4 per cent. based on 7,050 k.v.a.), situated in the basement below, Figs. 65, 66 and 67. Another oil switch serves for paralleling the two sets of bus bars. Of the two remaining oil switches, one controls the motor-driven exciters, and the other controls the auxiliary circuits. These can all be seen in the plan, Fig. 64. One 6,600-volt line on wood poles supplies power to Miena, and auxiliary transformers supply power to the Waddamana Village at 415/240 volts, and for station lighting at 110 volts. A 300 ampere hour battery is installed to supply power for emergency lighting and operation of the oil switches.

At the southern end of the switch gallery (Fig. 64), is located the control room commanding a complete view of the turbines and generators, and containing a control board of the bench type. Behind the bench board are vertical boards controlling all auxiliary D.C. circuits and accommodating the temperature indicating gear for generators and transformers. Above the bench board are placed all indicating instruments in connection with the main circuits. Electrically-operated remote control from the bench board is provided for all oil switches and generator field rheostats, the latter being situated in the basement below the switch gallery. The exciter field rheostats, situated on the turbine floor and the D.C. circuit breakers, situated in the cold air duct and controlling exciters and generator fields, are remote controlled, as are also the turbine governors.

The transformers and all extra high tension gear are situated in the open and are well shown in the views, Figs. 59 and 60, Plate LIX. In one row along the outside of the eastern wall of the turbine room are placed, as shown in Fig. 64, seven banks, each of three 6,600/88,000-volt, 2,333 k.v.a. oil-insulated water-cooled transformers, mesh connected on the low tension side and star connected on the high. Each transformer is fitted with flanged rollers and stands on rails on a concrete pedestal. Two spare transformers are provided and these can be rapidly substituted for a defective transformer by means of a carriage travelling on a track running along the full length of the transformer banks. A piping system enables the oil from any transformer to be rapidly drawn off to a 900-gallon storage tank situated in the basement, in case of fire, or for the purpose of passing the oil through a filter press. The system is so arranged as to permit of the oil in any one transformer being filtered without putting the transformers out of service. Temperature coils embedded in the windings of each transformer are connected to an indicator in the control room, in addition to which a metallic thermometer on each transformer operates an alarm in the event of an excessive temperature rise occurring.

From the transformers the current is led through hand-operated disconnecting switches and choke coils to the 88,000-volt buses, Fig. 64, from which it passes to the transmission lines through remote-controlled 88,000-volt oil switches, of which there is one set to each transmission line circuit. The 88,000-volt bus is provided with disconnecting switches, by means of which the section connected to any one transmission line can be isolated from the remainder of the bus. This arrangement permits any transmission line circuit to be connected for testing to a bank of transformers and a generator through the auxiliary 6,600-volt bus without interfering with the operation of the rest of the plant. At each end of the 88,000-volt bus, there are a set of aluminium cell arresters connected through a disconnecting switch and a horn gap. The 88,000-volt buses, choke coils, disconnecting switches and connections are supported on insulators, which in turn are supported by three lattice steel structures running parallel to the row of transformers (Figs. 64 and 60). The ground space between and around these steel structures is laid out in grass. On the southern side of the outdoor equipment there is an annex to the power house accommodating workshops and offices, and also a battery room in the basement.

(*To be continued.*)

BRITISH EMPIRE EXHIBITION: RAILWAY MATERIAL.—II.

THE exhibit of the Birmingham Railway Carriage and Wagon Company, Ltd., of Smethwick, consists of five passenger vehicles. Three of these are cars for the South African Railways and are shown on a track near the South African Pavilion, where they are coupled to a Metropolitan-Vickers electric locomotive built for the Pietermaritzburg electrification. The other two cars shown by the Birmingham Company are Pullman cars and are respectively a parlour and a buffet car. They are 65 ft. 5 in. long over vestibules and 62 ft. 4 in. over headstocks. They are for 4 ft. 8½ in. gauge. The bogies have a wheel base of 10 ft. and are centred 43 ft. 4 in. apart. The body width is 8 ft. 6 in., and height from rail to top of roof 12 ft. 5½ in. The wheels are 3 ft. 6 in. on tread. The parlour car has a total accommodation for 26 passengers, namely, 10 in the large saloon, eight in a small saloon, and four each in two private compartments. The buffet car has accommodation for 22 passengers, there being only one private compartment in this case. The timber in the framing is Indian gurgan, the cantrails and bottom sides being secured to the pillars by pressed knees, &c. Channel-section carlines are used.

The parlour car interior is finished in Indian padouk with quartered panels tastefully inlaid. The chairs are covered in moquette and the carpet is Wilton pile. The tables are of glass-covered quartered padouk. Each is fitted with a standard lamp with shade. The ceiling is domed and decorated with Adams mouldings. The buffet car is finished in similar style, but the chairs are covered with fancy blue-and-gold velvet and the carpet is blue Wilton pile. The lavatory compartments are in polished padouk, the floor being covered with decolite of marble pattern. The pedestal wash-basin is furnished with hot and cold supply. Westinghouse heaters are provided. The kitchen and pantry are equipped with sinks, hot and cold water, glass cupboards, drawers, gas-heated range, &c. The floors are laid with decolite. Water supply is carried in galvanised tanks in the roofs, and galvanised bins are furnished in the floors. An ice chest is fitted in the corridor. The coaches are dual fitted and have automatic central buffer and coupling gear. Heating is to the standard Pullman arrangement, and the electric supply on the Stone system.

The coaches built for the South African Railways comprise a kitchen car, dining car, and a special day and sleeping car. These coaches are for the standard South African gauge of 3 ft. 6 in., and are excellent examples of what can be accomplished on this track width provided the loading gauge is of liberal dimensions. An idea of the general appearance of the stock may be gathered from Fig. 28, which shows the day and sleeping car. An interior view of the dining car is given in Fig. 29. The latter car has a length over headstocks of 59 ft. 9 in., width of body at waist of 8 ft. 9 in., and a height from rail to top of monitor roof of 12 ft. 5⅛ in. The length of body over pillars is 60 ft. 3 in. The bogies are centred 44 ft. 6 in. apart, their wheel base being 6 ft. 1 in. The wheels are 2 ft. 10 in. on tread. The coach body is

SOUTH AFRICAN RAILWAY ROLLING STOCK; BRITISH EMPIRE EXHIBITION.

CONSTRUCTED BY THE BIRMINGHAM RAILWAY CARRIAGE AND WAGON COMPANY, LIMITED, ENGINEERS, SMETHWICK.

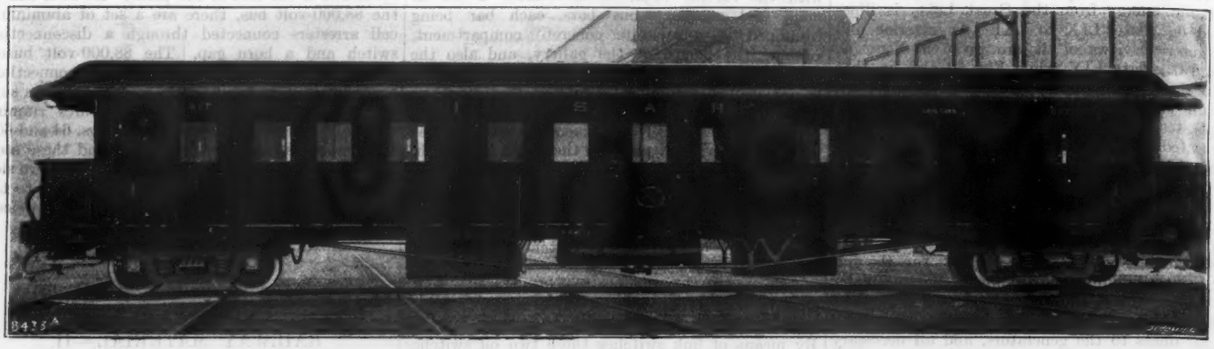


FIG. 28. DAY AND SLEEPING CAR.

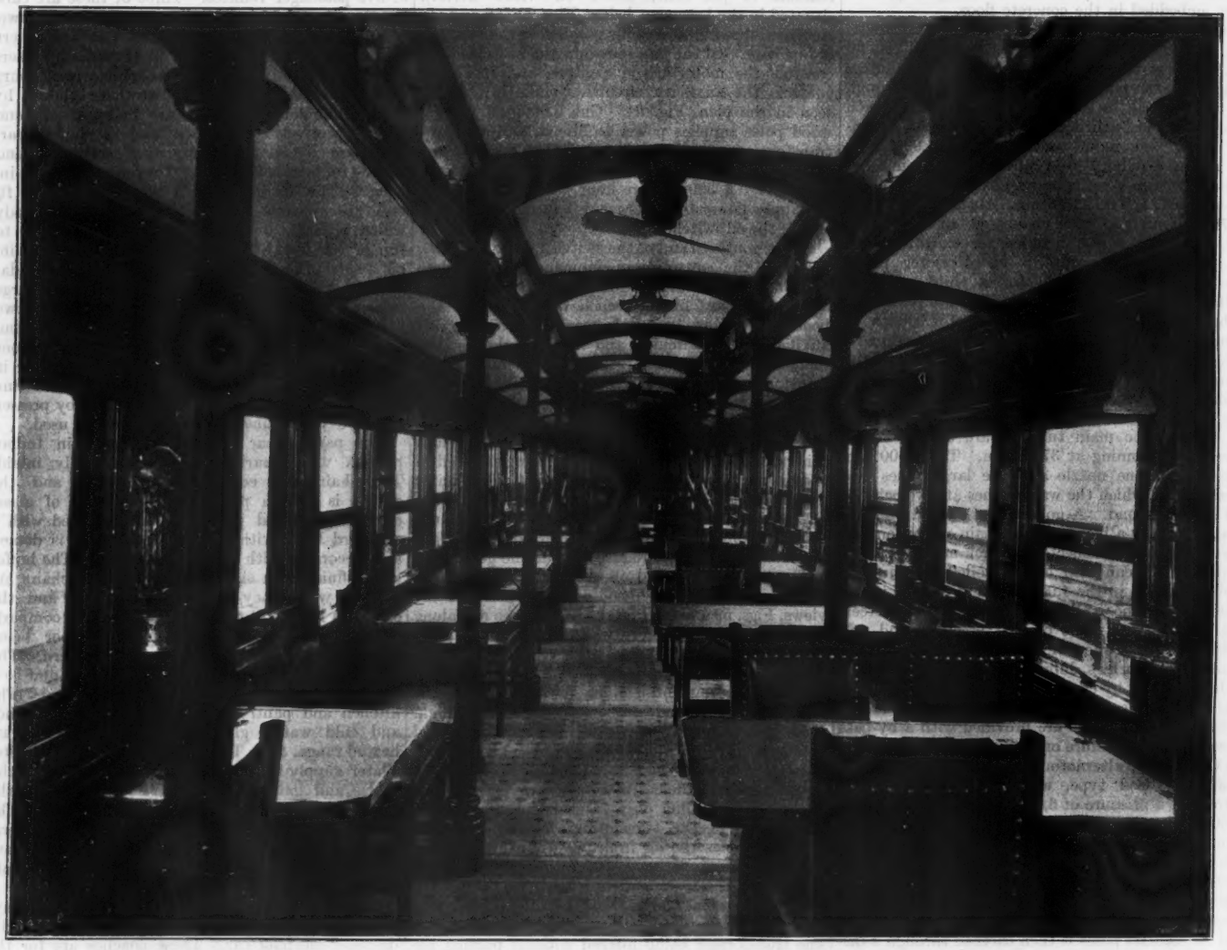


FIG. 29. INTERIOR OF DINING CAR.

of teak throughout, except for the floor and ceiling boards, which are of deal. The interior finish is in Spanish mahogany. The under-frame is of steel with four longitudinal truss rods and flitch plates along the sole-bars at the bogies. The car has one large saloon with a seating capacity for 46 passengers, while a small bar is arranged at one end. Provision for seating consists of 41 movable chairs and four fixed seats, the latter being placed at the cross-partitions and fitted with lockers below and a typewriter cupboard. The upholstery is standard green buffalo hide. The seats are arranged two on one side and one on the other of the car, with folding tables between. A feature of the interior is the series of fluted mahogany columns carried up to the monitor rail. The floor is laid with green-and-white marbled rubber tiling, and the gangway is covered with a carpet runner. Four bookcases are fixed to the body side under the monitor roof, and each quarter above the tables has a recessed metallic bottle cruet. The bar is equipped with display cabinets, ice cooler, refrigerator, safe, cupboards, &c.

This car is designed to run in connection with the kitchen car, in which living quarters for the staff are provided. The two cars together can provide continuous service of meals for 11 hours. The two cars communicate by means of a closed Pullman vestibule gangway. The kitchen has two coal-burning stoves and all necessary equipment. Next

SOUTH AFRICAN RAILWAY ELECTRIC LOCOMOTIVE; BRITISH EMPIRE EXHIBITION.

CONSTRUCTED BY THE METROPOLITAN-VICKERS ELECTRICAL COMPANY, LIMITED, ENGINEERS, MANCHESTER.

FIG. 30. TWO LOCOMOTIVES COUPLED TOGETHER.

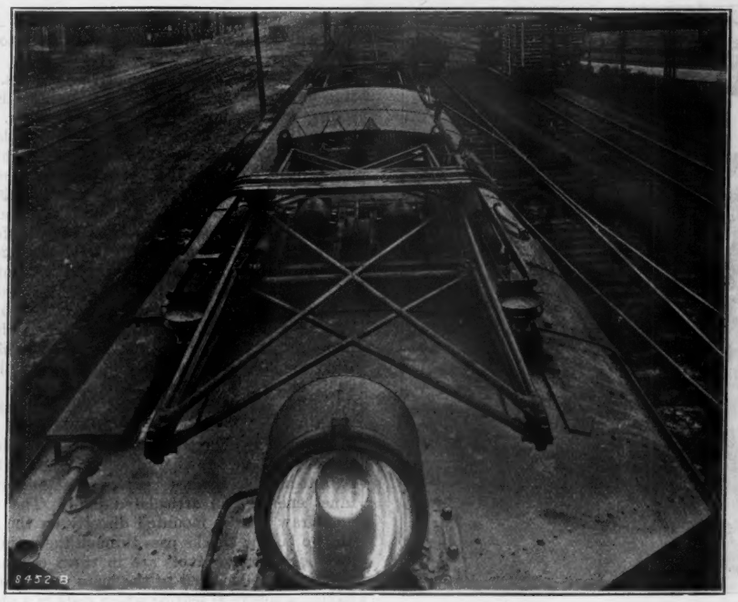


FIG. 31. VIEW OF ROOF SHOWING PANTOGRAPHS.

to the kitchen is a pantry, and these two compartments occupy half the length of the coach. The rest of the coach is given up to staff quarters, and consists of two half-compartments and a double compartment. Each is arranged for day or night use, the seats being adaptable, as on the first-class day and sleeping car, for forming upper and lower berths. There are two lavatories, one of which is arranged for native use only. At the exhibition the dining and kitchen car are in actual use for the purpose of serving meals.

The day and sleeping car has a length of 62 ft. 6 in. over headstocks, 57 ft. 6 in. over corner pillars, and 64 ft. 5½ in. over canopy roofs, this car having open end platforms as shown in Fig. 28. The bogies, which are the same for all the cars, in this coach are centred 47 ft. 6 in. apart. The accommodation is for 36 passengers seated and 26 sleeping. There are five double compartments and three single, with two lavatories fitted at the central crossover passage. The compartments open on to the corridors with sliding doors. Two of the single compartments are arranged with a sliding door in the dividing partition, and so can be converted into a double compartment when required. The double compartments have seats arranged with backs to hinge up to form upper berths, which are supported by straps and brackets. Heavy luggage racks are hinged to the cross-partitions and are suspended by leather-covered chains. When not in use and closed, the panelled front matches the rest of the interior. A folding table with mirror and a folding basin are also supplied, as well as parcels rack, hat pegs, &c. The single compartments are equipped similarly except that the folding basin and table are of the corner type. The upholstery is green buffalo hide. Messrs. Stone's system of lighting is installed, and low-pressure steam heating. Falling lights and louvres are provided at the windows, and additional ventilation is secured by means of hinged monitor roof lights protected by gauze screens.

The bogies for all these coaches are of the four-wheel equalising-beam type, built of rolled-steel sections and pressed plates. The bolster is of teak reinforced with two steel channels and mounted on quadruple elliptical springs, with triple-coil springs mounted between the solebars and equalising beams. The exterior of all these coaches is finished from the waist to bottom side rail with narrow vertical teak boarding.

The cars for South Africa just described are coupled at the Exhibition to an electric locomotive built by the Metropolitan-Vickers Electrical Company, Limited, of Trafford Park, Manchester. This firm is supplying 78 combined passenger and freight locomotives for the Glencoe–Pietermaritzburg main line electrification now in hand, these machines being of the $2-2+2-2$ type. This section, as is known, is being electrified, to deal with the heavy mineral traffic to the coast, the route of 171 miles traversing very hilly country,

SOUTH AFRICAN RAILWAY ELECTRIC LOCOMOTIVE; BRITISH EMPIRE EXHIBITION.

CONSTRUCTED BY THE METROPOLITAN-VICKERS ELECTRICAL COMPANY, LIMITED, ENGINEERS, MANCHESTER.

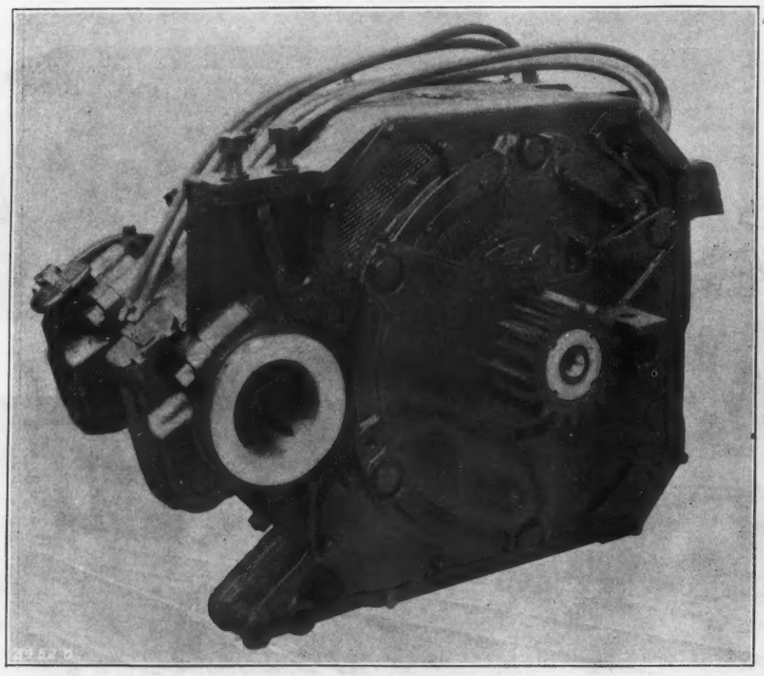


FIG. 32. ONE OF THE MAIN MOTORS.

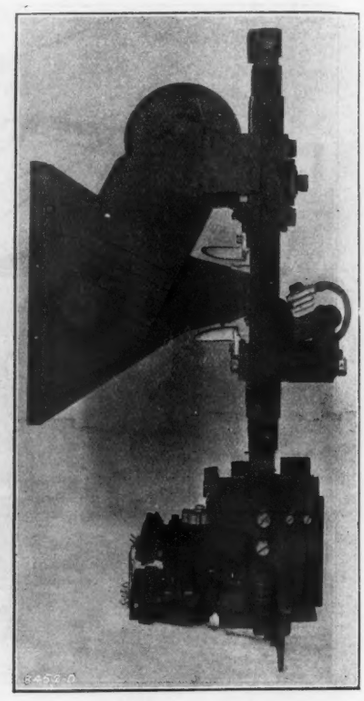


FIG. 33. 3,000-VOLT ELECTRO-PNEUMATIC SWITCH.

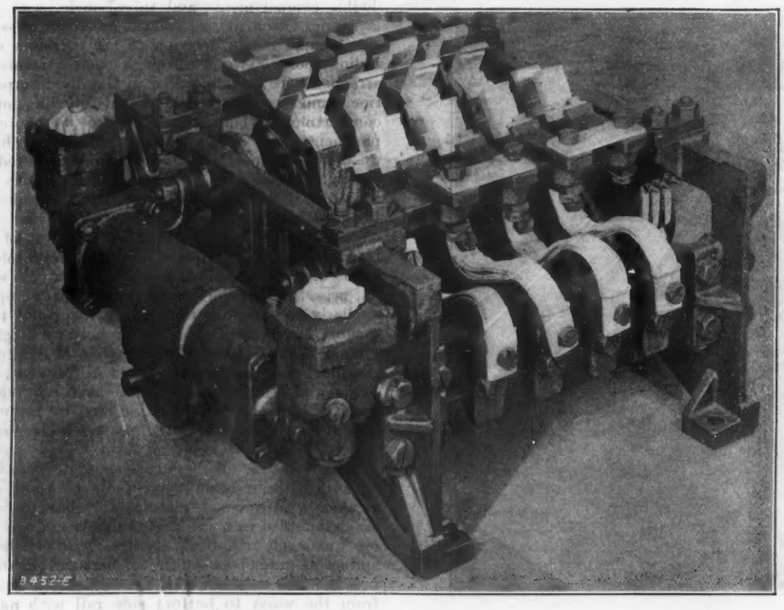


FIG. 34. CAM-OPERATED SWITCH GROUP.

and reaching an altitude of 5,000 ft. above sea level, falling to 2,200 ft. at Pietermaritzburg. In the latter section there is one grade falling 1,350 ft. in 14½ miles. The traction system is 3,000 volt d.c., with overhead contact and standard track return. The supply to sub-stations is at 88,000-volt 50-cycle three phase with overhead transmission. On account of the limitations of the gauge, which is only 3 ft. 6 in., and the curvature of the track, on which the minimum radius curves are of 300 ft., and also of the permissible axle loading, it was not possible to design a single locomotive to perform the duty required. The full trains, for normal operation, of 1,430 short tons, to Pietermaritzburg and 700 tons on the return journey, will be handled by three locomotives coupled together, controlled from one driver's cab. Advantage will be taken of the long down grades to utilise regenerative control.

We illustrate these locomotives in Figs. 30 to 40, on pages 597 to 600. Of these Fig. 30 shows two locomotives coupled together. Each locomotive weighs 66 tons 12 cwt., of which electrical equipment accounts for 27 tons 4 cwt., while the mechanical parts total 39 tons 8 cwt. There are four geared motors to each locomotive, of 300-h.p. capacity, making a total of 1,200 h.p. on one-hour rating for each machine. The tractive effort for one-hour rating, and for full field is 21,200 lb., with a maximum of 40,000 lb., and for continuous rating and full field is 16,400 lb., the speed being 21·5 m.p.h., with a maximum safe speed of 43 m.p.h. The overall length is 43 ft. 8 in., and height with pantograph lowered 12 ft. 11·3 in., while the width is 9 ft. 2¼ in. The total wheel base is 30 ft. 11 in., and the wheel base of the bogies 9 ft. 3 in., the distance between bogie centres being 21 ft. 8 in. The driving wheel diameter is 4 ft.

The main underframe carrying the electrical equipment and auxiliary gear is supported by two four-wheel bogies coupled together at their inner ends by an articulated joint. The buffing and draw gear is mounted directly on the trucks, and no buffing shocks pass through the main frame. The bogie centre pivots are in three castings, the upper one being fixed to the main underframe and having a spherical seating which rests in a phosphor bronze cup. The latter is held by a steel casting fixed to the bogie centre stay plates. On one bogie the cup is held rigidly, while on the other some longitudinal movement is allowed to provide for the position of the bogie on curves. Spring-loaded side and end bearers are also provided to control the relative movements of the bogies and underframe. The bogies are of frame plate construction with top and bottom stay plates at the ends and centres. The transom, in addition to carrying the bogie centre, also carries the motor nose suspension brackets. The main suspension springs are

ELECTRIC LOCOMOTIVE; BRITISH EMPIRE EXHIBITION.

THE METROPOLITAN-VICKERS ELECTRICAL COMPANY, LIMITED, MANCHESTER.

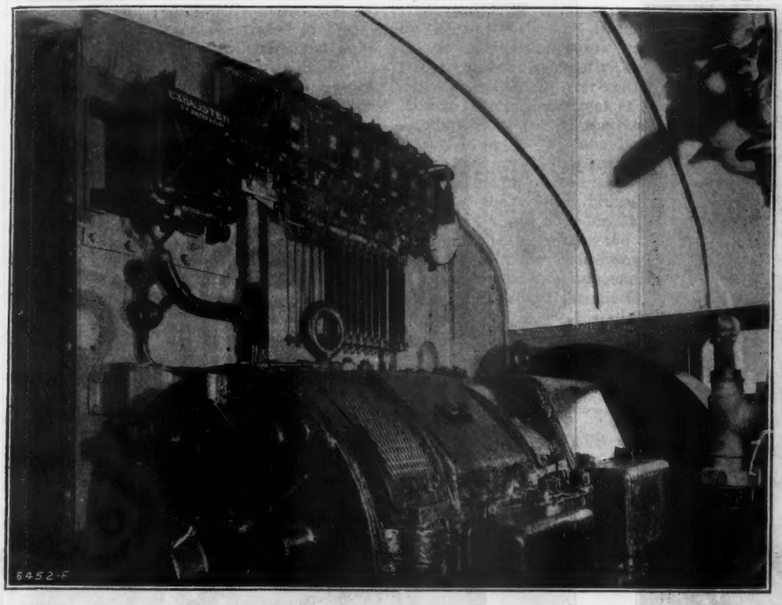


FIG. 35. 28-KW. MOTOR GENERATOR SET AND CONTACTORS.

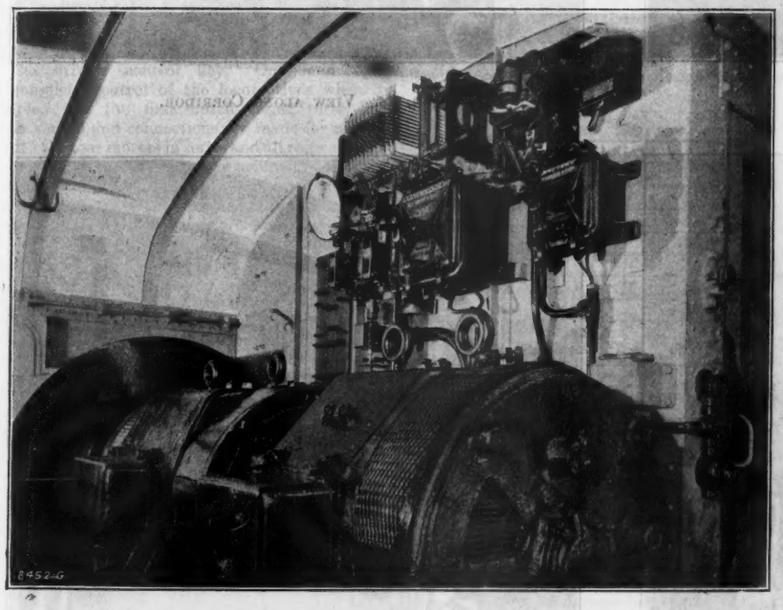


FIG. 36. 16-KW. MOTOR GENERATOR SET AND CONTROL GEAR.

laminated, the spring links being adjustable and fitted with compensating beams, as clearly shown in Fig. 30.

The main motors, of which a typical view is given in Fig. 32, are of the series-wound type, arranged for operation with two connected permanently in series, having thus 1,500 volts per commutator. The motors are designed to give the maximum output for the limited space available. The gear ratio is 17 : 75. The magnet frame is cast in one piece and is practically octagonal in shape. The motor is a four-pole machine with inter poles; a tapping is made in the main field to give reduction in excitation for running on weak field. Inspection covers above and below the commutator end give accessibility to the brushes when the motor is in position. Suspension is by the usual axle bearing on one side, the nose being carried on rubber springs in a suspension bracket on the bogie transom. The motors are force ventilated, air entering at the commutator end through a flexible duct from the blowers on the main frame, and flowing in parallel paths, leaving the machine through openings at the pinion end.

The body of the locomotive is divided into five compartments and a corridor. There is a driver's cab at each end, an interior view of one being given in Fig. 37, on page 600. In the cab are all the necessary controls, gauges, meters, brake valves, &c. In the centre of the machine is arranged the high-tension compartment, this being illustrated in Figs. 39 and 40. This compartment contains all high-voltage control gear, access from the corridor being by way of a sliding door which is mechanically and electrically locked while the pantograph is up. The spaces between the centre and end compartments are occupied by the auxiliary gear, including two motor generator sets, shown in Figs. 35 and 36, on this page, with blower, compressor, exhauster, reservoirs, low-tension switches, contactors, &c. The sections of the roof over these compartments and the clerestory roof above the high-tension compartment are removable so that the gear can be lifted out without difficulty.

Two pantographs are provided for each locomotive. They are shown in the raised position in Fig. 30 and in the lowered position in Fig. 31. Spring control ensures uniform contact pressure for varying height of the overhead conductor. The pantograph framework is carried on four insulators on heavy brackets. Air is supplied to the pantograph cylinders by an electrically-operated valve in the driver's cab. The pantograph control wires run through the train-line bundle, and the driver can control all pantographs from one cab. Each pantograph is capable of collecting current for all the motors, and only one need, therefore, be up at a time.

Current is led to the main equipment by way of a main isolating switch in the H.T. compartment. The isolating switch is connected, through a trolley overload trip, to the control equipment. The line and resistance switches are of the type shown in Fig. 33. They are pneumatically operated and have a contact pressure on normal working of 140 lb. To ensure a quick break the piston closes against a heavy spring. All parts of the switch carrying the main current are insulated for a working pressure of 3,000 volts to earth. These switches are arranged in two groups of 10 and 11 respectively, along the centre line of the locomotive. In the centre of the H.T. compartment are the cam-operated switch groups. These are illustrated in Fig. 34. These switches are operated by a double-ended piston carrying a rack engaging with a pinion on the camshaft. The cam groups are used for the motor combinations, forward and reverse, motoring and regenerating and the weak-field connections. Switch to switch and to resistance connections are bare copper rod or strap. H.T. cables are enclosed in steel conduits.

Above the switches are the resistance frames. They are of the cast grid three-point suspension and pressed-steel types, the latter being used for the stabilising resistances. The grids are carried by three insulated bars, held by insulators in end frames, the frames again being insulated from the supporting beams. The H.T. compartment further contains electro-magnetic contactors for starting up the motor generator sets, the auxiliary fuse groups, shown in Fig. 40, page 600, which are of the expulsion type and are graded in steps with suitable resistances, as well as motor overload and over-voltage relays and other H.T. gear.

The master controllers in the driver's cabs have three independent drums on one central spindle. These drums are used for the motor combinations, series and parallel forward, series in reverse, acceleration and regeneration, respectively. Complete mechanical interlocking is adopted; no blow-out coils are required since the currents used for energising the valve magnets are very low and the control is on a 100-volt circuit. The control equipment can be completely isolated by a multi-point cut-out switch. Defective motors are cut out by motor cut-out switches connected in the control circuit.

The auxiliary gear comprises two motor generator sets, one of 16-kw. and one of 28-kw. capacity. The motors are similar in having two distinct windings connected to a commutator at each end of the armature, the two commutators being connected in series externally. The motor fields are in series with the L.T. side of the commutator and also with the series fields of the generators. The 28-kw. set, shown in Fig. 35, on this page, is used for exciting the fields of the main motors during regeneration. The motor and generator have a common shaft, at the end of which is a fan supplying air to two of the

SOUTH AFRICAN RAILWAY ELECTRIC LOCOMOTIVE; BRITISH EMPIRE EXHIBITION.

CONSTRUCTED BY THE METROPOLITAN-VICKERS ELECTRICAL COMPANY, LIMITED, ENGINEERS, MANCHESTER.

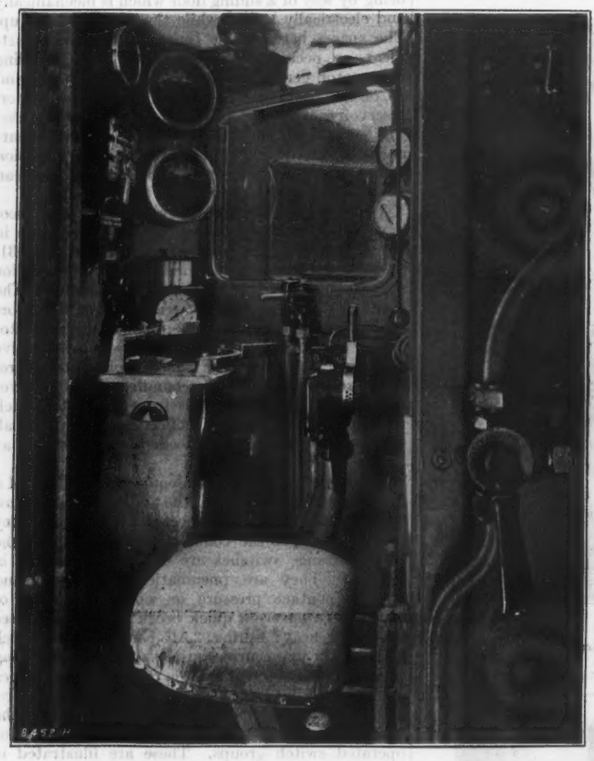


FIG. 37. DRIVER'S CAB.

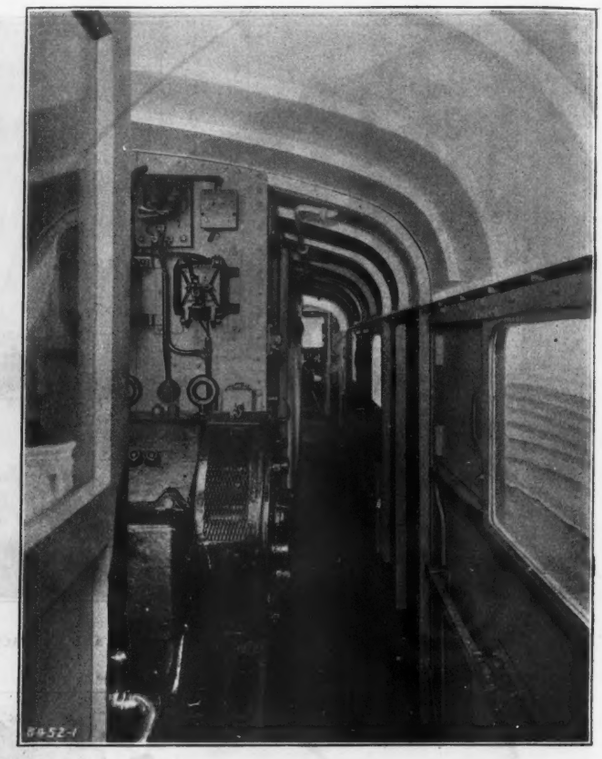


FIG. 38. VIEW ALONG CORRIDOR.

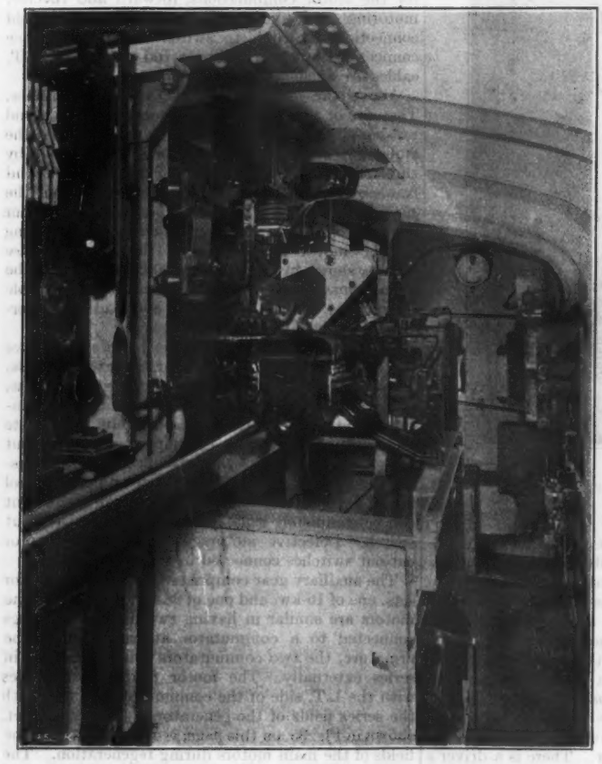


FIG. 39. H.T. COMPARTMENT SHOWING CAM GROUP.

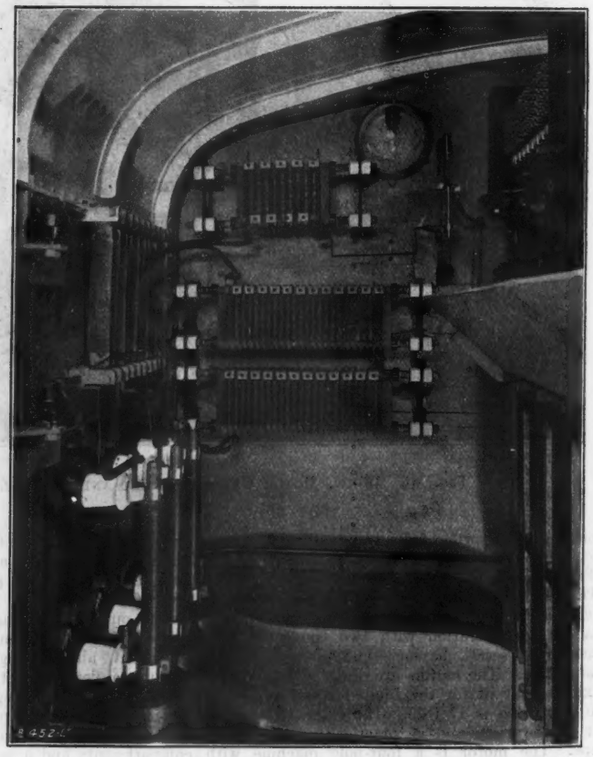


FIG. 40. AUXILIARY FUSE GROUP.

main motors. The motor has a shunt holding winding connected across the L.T. supply, and the generator has a shunt winding in series with a regulating resistance, which is cut out step by step by electro-magnetic contactors actuated by the regeneration drum on the master controller, the winding being connected directly across the L.T. generator. The 16-kw. set, illustrated in Fig. 36, page 599, supplies the control circuits, lights, exhauster, compressor, excitation circuit for the larger generator, cab heaters, and maintains the battery on charge. In this set the motor and generator frames are separate, but stand on the same bed-plate. A fan on the end of the motor shaft supplies air to the remaining two main motors. The two motor generators are connected in series with starting resistances connected through a double-break contactor to the 3,000-volt auxiliary fuses. Normally both sets are running, but it is possible to cut out the larger set, in which case interlocking prevents regnerative working.

The compressor is a horizontal two-cylinder machine geared to an 8-h.p. series wound motor. Simultaneous control of all compressors is obtained by a synchronising wire connecting up the compressor governors which are connected in the control circuit. The compressors supply air to the brakes, sanders, horns, control gear and pantographs. The exhauster is of the rotary drum type, direct-coupled to a series wound motor with a tapped field. The motor is rated at 4 h.p. at 1,400 r.p.m. and 6 h.p. at high speed. An electro-magnetic contactor operates the tap field and is in turn actuated by a switch, which is closed when the vacuum brake valve is in release. Both compressor and exhauster motor are connected across the L.T. supply and are switched into circuit through a double-pole switch fuse.

The main motor control is arranged for series and parallel in a forward direction, series in reverse, and series and parallel in regeneration. The positive feeds to all switches and to the exhauster control circuits and sanders pass through the combination drum of the master controller operated by the drivers control key. One man thus has complete control of the locomotives when in multiple. On the first notch series three line switches close and connections are made for motoring with the four motors in series and all resistance in. The control interlocking is so arranged that the cam groups must throw to their correct positions before the unit switches close, thus preventing the possibility of the cam switches breaking any current. The resistance is cut out step by step by moving the accelerating handle to consecutive notching points. The accelerating handle has a detent and lever. A slight pressure on the lever withdraws the detent from the slot, and the release of the lever allows it to engage automatically with the next tooth. A slight pull on the handle moves it forward until the detent automatically engages the next slot. The arrangement ensures accurate notch to notch movement.

The control circuit is interlocked to prevent starting in motoring with parallel connections. To make transition, the combination handle is moved to the parallel position, no change of connections taking place. All resistance is inserted by moving the accelerating handle to the first notch; the cam group then commences to throw to parallel. It short circuits two motors, and its travel is then arrested until the short circuit is opened by a unit switch. Then it completes its travel and the parallel switches close. The resistance is cut out step by step as before and weak field can be taken if desired.

In regeneration all four main motors are used as generators with separate excitation. The 28 kw. motor generator is used for this. The generator maintains constant voltage with variation of load, and its excitation varies in proportion to the line voltage; the latter feature is obtained from the 16 kw. set. By means of the contactors connected to the field regulating resistance of the 28 kw. generator thirteen different steps of voltage are obtained under the control of the regenerative handle of this master controller. The driver is able to come into regeneration either with his motors in series or in parallel, the former over the lower ranges and the latter over the higher ranges of speed. When taking regeneration all resistance is inserted in the motor circuit and the regenerating connections are made with the fields under minimum excitation. The driver then cuts out his main resistance and brings up his excitation until the train is held at a steady speed on the down grade. Whilst regenerating, the driver can make partial application of the train brakes, the locomotive brakes being cut out by the control circuit. If, however, his application is too great, the power circuit is immediately tripped and the locomotive brakes apply themselves automatically. An over-voltage relay protects the motors generating current at excessive voltage.

All rolling stock on the South African Railways is fitted for the vacuum brake, but the electric locomotive brakes are compressed air.

By means of a vacuum operated air valve, application of the vacuum brakes will produce a proportional application on the locomotive. For shunting, the driver uses the compressed air brake valve only. Air connection is possible between the locomotives as a safeguard against compressor failures. Sanding is arranged for multiple control. Complete lighting is installed, supplied from the 100 volt circuit fed by the 16 kw. generator, in parallel with a 100 volt battery. A high power head light is carried at each end.

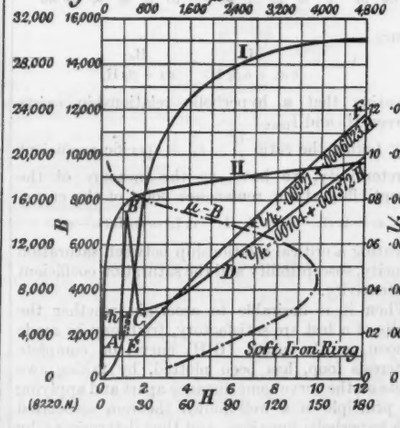
THE ELEMENTS OF MAGNETIC ANALYSIS.

By ELLIS H. CRAPPER, M.Eng., M.I.E.E.

(*Continued from page* 454.)

Frölich's Law and Equations.—A very noticeable feature in connection with the fact that permeability is a variable function of the flux-density was, for a long time, the difficulty experienced in formulating an expression giving the quantitative variation in the values of the permeability with increasing values of flux-density B, in anything like a rational formula, and the difficulty was first solved by Lamont in 1880, when he introduced the idea of magnetisability. In his endeavour to form a relationship, which represented the connection between the various elements associated with the design of electrical

Fig. 8.



machinery, he suggested the theory that "the value of the permeability of a magnetic substance is proportional to the difference between the saturation value (*i.e.*, the maximum possible value) of the flux density B_s, and the actual value of the flux-density B, corresponding to a given value of H, or algebraically

$$\mu = k\,(B_s - B)$$

The quantity $(B_s - B)$—*i.e.*, the magnitude of the flux density which the material is still capable of taking up by increasing the magnetising force until complete saturation is obtained—obviously represents the magnetisability of the material for the condition under consideration.

Taking Lamont's law as the basis for obtaining the various quantitative relationships existing between the more important magnetic elements, the following equations are readily derived:—

Since $\mu = \frac{B}{H}$, we have $B\left(\frac{1 + k\,H}{H}\right) = k\,B_s$,

whence $B = \frac{H}{\frac{1}{k\,B_s} + \frac{H}{B_s}}$

By denoting $\frac{1}{B_s}$ by b, and $\frac{1}{k\,B_s}$ by a,

we get $\frac{H}{B} = a + b\,H$.

$$\therefore \quad B = \frac{H}{a + b\,H} \qquad . \quad . \quad . \quad . \quad . \quad . \quad (1)$$

and $\mu\,H = \frac{H}{a + b\,H} \quad \therefore \quad \frac{1}{\mu} = a + b\,H \qquad . \quad (2)$

This is the algebraic statement of Frölich's law or equation introduced in 1882, as an expansion of Lamont's theory. It gives the relationship existing between the reluctivity (*i.e.*, the reciprocal of permeability) and the magnetising force as a perfect linear equation, and experience has proved that it agrees satisfactorily with experimental results for ordinary values of H as indicated in Fig. 8. It fails, however, at low and high values of flux-density, as it must naturally do inasmuch as $B = 4\,\pi\,I + H$; B obviously cannot attain a saturation value so long as H increases. The constant $I = \frac{B - H}{4\,\pi}$ previously mentioned, is termed the intensity of magnetisation, and is defined as the magnetic moment per unit volume of the magnet. When a magnet is magnetised to saturation, the intrinsic value of the intensity of magnetisation is denoted by the symbol I_s, which is probably the most important element associated with a magnet so far as the material is concerned.

With respect to Frölich's law, Dr. A. E. Kennelly was the first to point out that by dividing the total inductivity B into two components, (*a*) the flux-density contributed by the molecules of the metal, which he designates the ferro-magnetic density or ferric-inductivity B_i, it may be considered as separate and distinct from (*b*) the component contributed by the ether in the space occupied by the material, which may be denoted by B_e. The ferric-reluctivity, therefore, is denoted by $\rho_i = \frac{H}{B_i}$, whilst for the ether portion, or space lattice, B_e increases directly as H increases, or $B_e = H$ in all cases, since the permeability of the space lattice is unity. Thus,

$$B = B_i + B_e \text{ and } \mu\,H = \mu_i\,H + \mu_e\,H$$

$$\therefore \quad \mu = \mu_i + \mu_e \text{ and } \mu_i = \mu - \mu_e = \mu - 1, \text{ since } \mu_e = 1$$

$$\therefore \quad \frac{1}{\mu_i} = \frac{1}{\mu - 1} = \rho_i \qquad . \quad . \quad . \quad . \quad . \quad . \quad (3)$$

Consequently,

$$\rho_i = \frac{1}{\mu - 1} = a + b\,H.$$

By a simple algebraic transformation, equation (1) gives

$$H = \frac{a\,B}{1 - b\,B} \qquad . \quad . \quad . \quad . \quad . \quad . \quad (4)$$

This relationship is a form of the equation to a rectangular hyperbola, since it is equivalent to

$$(H + a\,B_s)\,(B_s - B) = a\,B_s^2 = \text{a constant} \qquad . \quad (5)$$

It follows from equations (4) and (5) that the curve B / H, *i.e.*, the usual curve obtained by plotting values of B against H, is a perfectly definite curve, and that the values of B are hyperbolic functions of the magnetising force H. This relationship is the fundamental feature of all magnetisation problems. Dr. Steinmetz suggests that the constant (*a*) in Frölich's equations is characteristic of the magnetic hardness of the material, and terms it the coefficient of magnetic hardness. The constant *b* fixes the inclination of the straight line, and furthermore is numerically the reciprocal of the saturation value of the flux density, provided that a high value of $H_{max.}$ is applied during the test.

It will be obvious, from the principle introduced by Dr. A. E. Kennelly, that the measure of the intrinsic magnetisation of a material is more correctly represented by the intensity of magnetisation I_s, than by the measure B_s, especially in the case of permanent magnets. Logically, intensity of magnetisation I, is the only suitable constant to apply when dealing with the nature of a magnetic material, and that measures in terms of B should be reserved for the purposes of the design of electro-magnetic appliances.

With reference to the relationships associated with intensity of magnetisation, the relation $\frac{I}{H}$,

termed the coefficient of magnetisation, or the susceptibility of the material, is analogous to permeability, and is denoted by $\kappa = \frac{I}{H}$, and the numerical relationship existing between κ and μ is

$$\kappa = \frac{\mu - 1}{4\pi} = \frac{\mu_i}{4\pi} = \frac{1}{4\pi\rho_i} \quad . \quad (6)$$

Having suggested that $\mu_{max.}$ is a critical constant of a magnetic material, it is proposed that $(B_s - B_\mu)$ or preferably $(I_s - I_\mu)$ be the measure of the magnetisability of a material, and be expressed in terms of lines of intensity of magnetisation per square centimetre. The principle of using I_s as the intrinsic measure of magnetisation requires that equations (1), (2) and (4) be expressed as follows :—

$$I = \frac{H}{\alpha + \beta H} \quad . \quad . \quad . \quad (1a)$$

$$\frac{1}{\kappa} = \alpha + \beta H \quad . \quad . \quad . \quad (2a)$$

$$H = \frac{\alpha I}{1 - \beta I} \quad . \quad . \quad . \quad . \quad (4a)$$

and that

$$(H + \alpha I_s)(I_s - I) = \alpha I_s^2 = \text{a constant} \quad (5a)$$

Consequently, the curve I/H, obtained by plotting I against H, is a hyperbolic curve, and it may be readily shown that $\alpha = 4\pi a$ and $\beta = 4\pi b$, if Lamont's law be expressed as $\kappa = k(I_s - I)$, which is rigidly correct and convenient.

A number of equations are given for magnet steels in the numerous tables which follow, and as an example of the equation for soft iron, Messrs. J. Sankey and Sons, Limited, give as the equation for

Fig. 9.

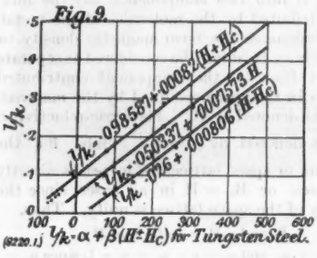
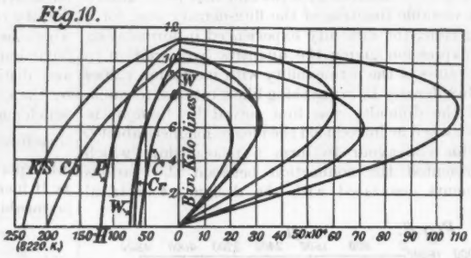


Fig. 10.



Stalloy, applicable between the limits of 4 kilolines and 14 kilolines per square centimetre, the following equation :—

$$H \text{ (ampere turns per cm.)} = \frac{0 \cdot 104\, B}{1 - 0 \cdot 066\, B}$$

This form of Fröhlich's equation is the basis of the working relationships associated with the design of transformers and other electrical appliances.

With respect to permanent magnets, it is well recognised that the nature of the curvature of that portion of the cyclic diagram between the remanence and coercivity points is, from the point of view of investigating the working quality of a magnet, more productive of information than any other part of the loop, and attention is now drawn to a most useful application of Fröhlich's equation, introduced by Mr. E. A. Watson, M.Sc., A.M.I.E.E., who, dealing with the complete descending positive portion of the hysteresis loop, gives the form of Fröhlich's equation as follows :—

$$\frac{H + H_c}{B} = \alpha + \beta (H + H_c)$$

and, by plotting $\frac{H + H}{B}$ against H, a perfect straight line is obtained, as shown in Fig. 9, indicating the hyperbolic relationship perfectly, for the ascending curve, descending curve and positive return curve; there are thus three equations, for each sample of magnetic material.

It may be mentioned here that the demagnetisation curve between the remanence and coercive force points enables the designer to obtain a measure of the external magnetic energy available in the magnetic field between the pole pieces of a magneto magnet. Mr. S. Evershed, M.I.E.E., has shown that, by taking the products of the successive values of the demagnetising force, — H, into the corresponding values of B, as given by the demagnetisation curve, a series of energy products $\beta\phi$, are obtained which, when plotted as shown in Fig. 10, give the measure of the maximum value of the product of B and — H. This product $(\beta\phi)_{max.}$ is a most important constant of a permanent magnet, and enables one to compare the relative qualities of different magnets, and also to determine the economic volume of the steel required for a magnet designed for a specific purpose. The $(\beta\phi)$ curves for six samples of representative permanent magnet steels, *i.e.*, carbon, chrome, tungsten, Permanite, cobalt and KS cobalt are given in Fig. 10. The actual values of $(\beta\phi)_{max.}$, remanence, coercive force, together with Fröhlich's equations for these materials, will be considered later.

Assuming that the maximum value of the applied magnetising force, $H_{max.}$, is sufficiently high, several very important relationships are readily deduced. Thus,

$$\kappa_r = \frac{I_r}{H_c} = k_r (I_s - I_r)$$

$$I_r = \frac{H_c}{\alpha + \beta H_c} \text{ as in equation } (1a)$$

$$\frac{1}{\kappa} = \alpha + \beta H_c \text{ (straight-line law)}$$

$$\text{and } H_c = \frac{\alpha I_r}{1 - \beta I_r} \text{ as in equation } (4a)$$

the magnitudes of the constants, α and β, being fixed by the new conditions.

When $H_{max.}$ is sufficiently high, let

$$\frac{I_r}{I_{max.}} = c = \text{coefficient of retentivity.}$$

Then since

$$\frac{H + H_c}{I_r} = \alpha + \beta (H + H_c) = \frac{I}{\kappa_r}$$

we have

$$I_r = \frac{H_c}{\alpha_1 + \beta_1 H_c} = c I_{max.}$$

whence

$$I_{max.} = \frac{H_c}{c\alpha_1 + c\beta_1 H_c} = \frac{H_c}{\alpha_2 + \beta_2 H_c}$$

indicating that a hyperbolic relationship exists between H_c and I_{max}.

By taking the ratio $\frac{I_r}{I_s} = c_s$ = specific coefficient of retentivity, we have, as the measure of the susceptibility at the remanence point of the curve,

$$\kappa_r = k_r (I_s - I_r) = k\ (I_s - c_s I_s) = k_r I_s (1 - c_s)$$

indicating a critical relationship between saturation intensity, susceptibility and the saturation coefficient of retentivity.

When it is desirable to ascertain whether the results of a test are satisfactory, trial may be made as soon as the usual (B/H) curve, or complete hysteresis loop, has been plotted, by taking two points on the curve some distance apart and applying the principle of a well-known theorem associated with hyperbolic functions, and thus determining by calculation whether the relationships between B and H or I and H are hyperbolic. Let (H_1, I_1) and (H_2, I_2) denote the constants which fix the two points on the curve; then, by taking a third point (*i.e.*, H_3, I_3) on the curve between them, such that $H_3 = \sqrt{H_1 \times H_2}$, a value of the intensity of magnetisation, I_3, is obtained, which should be in perfect agreement with the plotted results. Thus, in a certain case, the descending curve, $[1 - (H + H_c)]$ for a sample of hardened steel, gave $I_1 = 772 \cdot 7$ for $H_1 = 73 \cdot 6$ and $I_2 = 642 \cdot 7$ for $H_2 = 63 \cdot 2$. The equation relating to this part of the loop was $\frac{1}{\kappa} = 0 \cdot 027622 + 0 \cdot 000925\ H$.

The value of

$$H_3 = \sqrt{H_1 \times H_2} = \sqrt{73 \cdot 6 \times 63 \cdot 2} = 68 \cdot 2$$

and consequently

$$\frac{1}{\kappa_3} = 0 \cdot 027622 + (0 \cdot 000925 \times 68 \cdot 2) = 0 \cdot 090707$$

and

$$I_3 = \frac{H_3}{\alpha + \beta H_3} = \frac{68 \cdot 2}{0 \cdot 090707} = 752$$

The actual value of I_3 given by the curve for $H = 68 \cdot 2$, was 756.

Then, again, the fundamental relationship of the rectangular hyperbola, expressed in terms of the essential magnetic constants, is as follows :—

$$(H + a I_s)(I_s - I) = a I_s^2$$

and since,

$$I_s = \frac{1}{b}, \text{ we have, when } I = \tfrac{1}{2} I_s$$

$$\left(H_1 + \frac{a}{b}\right)\left(\frac{I_s}{2}\right) = \frac{a}{b^2}$$

$$\left(H_1 + \frac{a}{b}\right)\left(\tfrac{1}{2}\,\frac{1}{b}\right) = \frac{a}{b^2}$$

whence

$$H_1 = \frac{a}{b}$$

Hence the following theorem :—

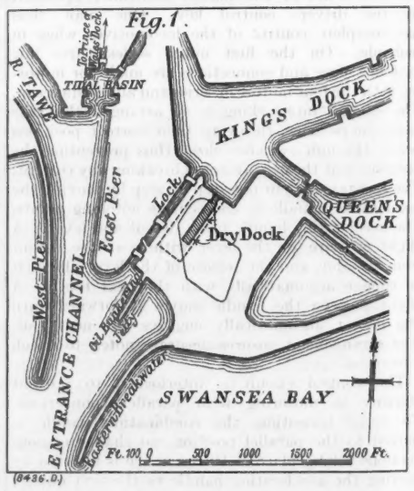
When the constants a and b in the equation $\frac{1}{\kappa} = a + b\,H$, correspond to the saturation value of the intensity of magnetisation, the magnitude of the magnetising force H_1, corresponding to the intensity $\frac{1}{2} I_s$ is given by $\frac{a}{b}$.

(To be continued.)

THE NEW PALMER'S GRAVING DOCK AT SWANSEA.

SWANSEA occupies a very important position among the ports of the country, and has a record of continuous expansion extending over many years. The dock system is of considerable magnitude and of modern type, the largest of its wet docks being the King's, which was completed in 1909. This dock, in conjunction with the adjacent Queen's Dock and various subsidiary docks, has a water area of about 250 acres. The entrance lock to the King's Dock system can accommodate

Fig. 1.



most modern shipping, being 875 ft. long and 90 ft. wide, with a depth of 33 ft. at high water spring tides over the inner sill. When the King's Dock works were carried out it was realised that an addition to the dry dock facilities of the port would sooner or later be necessary, and a site of suitable dimensions, and in a convenient position, was reserved for future utilisation for this purpose.

The growth in the size of ships utilising Swansea in recent years has been so great that the demand for a large graving dock became very pressing, and early in 1922 Messrs. Palmer's Shipbuilding and Iron Company decided to construct a large graving dock and ship and engine repair works at the port. For this purpose a subsidiary company, bearing the title Palmer's (Swansea) Dry Dock Company, Limited, was formed, and a contract was placed with Messrs. Sir John Jackson, Limited, for the construction of a graving dock 560 ft. long with a 75-ft. entrance, and having 26 ft. of water

PALMERS' NEW GRAVING DOCK AT SWANSEA.

MR. N. G. GEDYE, M.INST.C.E., WESTMINSTER, CONSULTING ENGINEER; MESSRS. SIR JOHN JACKSON, LIMITED, CONTRACTORS.

Fig. 2.

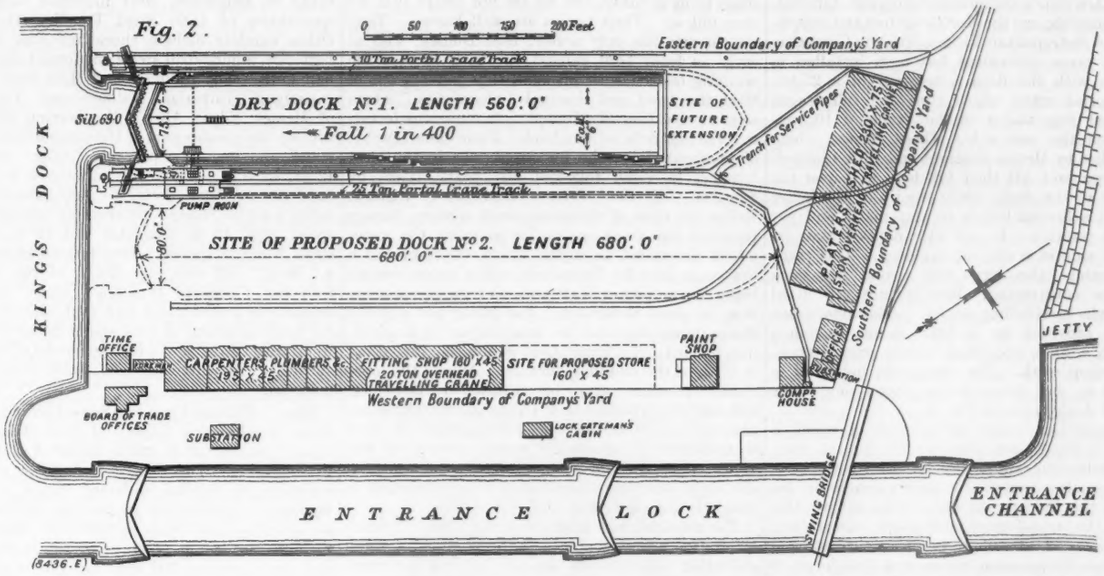
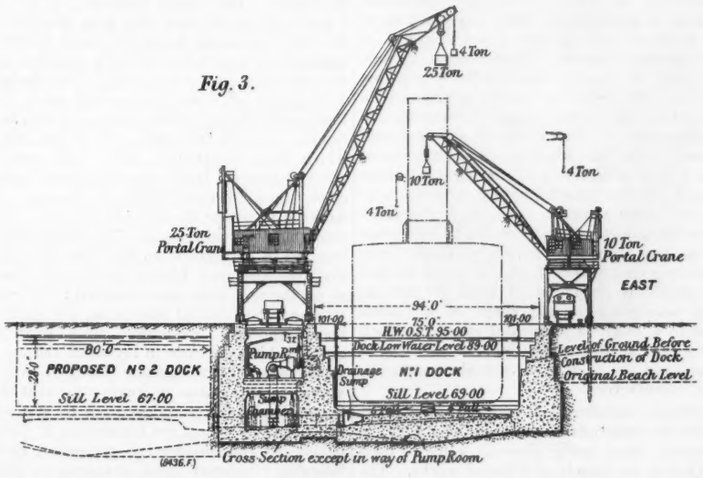


Fig. 3.



over the sill at high water spring tide. The dock, which has been completed and is to be opened on the 14th instant by Lady Pole, wife of Sir Felix Pole, General Manager of the Great Western Railway, has been constructed on the site which had been reserved for the purpose. This new dock has a clear width of entrance considerably greater than that of any other dry dock in the South Wales and Monmouthshire ports, the largest previously existing dry dock being the No. 2 dock at Barry, which has an entrance 69 ft. 6 in. wide. Some of the other docks with narrower entrances are longer than the new Swansea dock, but arrangements are such that this can be lengthened in the future should the development of shipping make this desirable. We will refer more fully to this feature of the dock when dealing with the details. The whole of the work has been carried out to the designs of, and under the superintendance of, Mr. N. G. Gedye, of Westminster, who acted as consulting engineer to Messrs. Palmer.

In describing this interesting and important piece of work we propose in the first instance to give a general account of the new dock and its equipment, passing afterwards to a more detailed consideration of the constructional work. A key plan showing the situation of the new dock in relation to the King's Dock and the entrance for Swansea Bay is given on the opposite page. As will be seen, the dock lies alongside the entrance lock by which ships can enter the King's Dock from the sea at any state of the tide. Ample turning space is available in the King's Dock for ships entering or leaving the dry dock. The level of water in the King's Dock is maintained normally at the level of high water ordinary spring tides, and does not fall at any time more than 5 ft. below that level, so that the largest ships which can be accommodated can enter or leave the dry dock at practically any time. The Great Western Railway Company proposes to instal a powerful pumping plant at their Swansea docks for the purpose of maintaining the water level in the King's Dock and Prince of Wales's Dock systems at the level of high water spring tides, and when this installation is in operation the depth of water over the dry dock sill will be maintained constantly at 26 ft.

A plan of the dock is given in Fig. 2 and a cross section in Fig. 3 above. As will be seen from Fig. 2, the site which is covered by Messrs. Palmers' repair yard contains space for a second dry dock of somewhat longer dimensions than that which has been constructed. All arrangements in connection with piping layouts and other such features have been made on the assumption that this second dry dock will be constructed in the future. The works comprising the King's Dock system were constructed on an area of foreshore which was reclaimed by the construction of a sea embankment. The area between the south quay wall of the King's Dock and the sea embankment had not at the time of the completion of the King's Dock been completely filled up, and a large portion of the site now occupied by the ship reparing yard and dry dock was submerged. The area was cut-off from the King's Dock by a quay wall. As will be gathered from Fig. 1, Messrs. Palmers' Yard does not cover the whole of this isolated site, and that part outside their boundary fence is still unfilled and partly under water. When the work was put in hand a line of sheet steel piling was driven on the east side of the future yard, and a sheet piling cofferdam was built enclosing the future entrance. We will refer more fully to these features of the work when dealing with the details of the constructional work.

The dock is constructed entirely in concrete with the exception of the quoin and sill stones, which are of granite. The gates are of steel and are of the semi-buoyant type, watertight air chambers being constructed in the lower part of each leaf, the upper part of each leaf consisting of a water-ballast chamber into and out of which the water is free to flow as the level of the water inside the dock rises or is lowered. A view of the completed gates is given in Fig. 5 on page 610. The gates are operated by 10-in. hydraulic rams. To facilitate the warping of ships in and out of dock two 5-ton hydraulic capstans are installed at the entrance and another of 7 tons capacity at the inner end of the dock, while bollards are provided at suitable intervals throughout the length on each side. The gates and capstans were supplied by Messrs. Sir W. G. Armstrong, Whitworth & Co., Ltd. A valuable and convenient feature has been introduced in connection with the arrangement of the keel blocks, These are of cast iron placed at 3-ft. 3-in. centres and are mounted on longitudinal timber bearers in groups of four, so designed that they can be removed to repair ship's bottom damage without resorting to the laborious cutting out required by the old-fashioned timber type of block (Fig. 5).

The dewatering of the dock is carried out by two 36-in. centrifugal pumps placed in a pump chamber built in the western wall near the entrance. This chamber is shown in Figs. 2 and 3. Working together the two pumps can discharge the capacity of the dock, 1,356,000 cub. ft. of sea water, in 2½ hours. Each pump is driven by a 280-h.p. 440-volt, three-phase motor. The pump-room also contains a 10-in. dock-drainage pump and a 9-in.

ballast pump which connects with a 10-in. main extending along the western side of the dock, from which water for testing tanks and cleaning purposes can be tapped from valve-boxes placed at intervals along the dock side. The pumps were supplied by Messrs. Gwynne's Engineering Company, Limited, of Hammersmith, and the electric motors and switchgear by the Metropolitan Vickers Electric Company. An ample crane equipment has been installed in connection with the dock, consisting of a 25-ton electric portal crane which runs the full length of the west side and a similar crane of 10 tons capacity on the east side. These cranes, which were supplied by Messrs. Stothert and Pitt, Limited, of Bath, can each lift their full load well over the centre line of the dock, while the jib of the larger crane is of sufficient length to step masts and put funnels in position. It can also deposit material on the far side of a ship in the dock. This crane will ultimately also serve the second dry dock when it is constructed. Both cranes are fitted with a Toplis level-luffing device. Additional crane service is provided by a 3-ton steam travelling crane with a 45-ft. jib, which covers general dock-side and shop work. The cranes are indicated in Fig. 3 and are well shown in the general view of the completed dock given in Fig. 4.

The compressor house, the position of which is indicated in Fig. 2, contains two 500 cub. ft. compressors delivering air at 100 lb. per square inch. The house also contains a motor-generator for supplying the lighting service. Adjacent to this house is the transformer step-down sub-station, which receives 12,000-volt three-phase current from the Swansea Corporation mains and transforms it down to 440 volts for supplying the dock and works. Along the western side of the site, as shown in Fig. 2, are situated shops for joiners, carpenters, plumbers, fitters, blacksmiths and painters, together with a foundry and general stores and time offices. The various shops are fitted out with a very complete equipment of machine tools, and any class of ship-repair work can be dealt with. The fitting shop contains lathes and boring, screwing, shaping and planing machines, and is served by a 20-ton overhead electric travelling crane. The plater's shop, situated at the south end of the site, is equipped with bending rolls, punching and shearing machines, plate mangles, countersinking and plate edge-planing machines, a beam bender and angle-cutting machine, and a large plate and bar furnace with bending blocks. An interesting piece of the equipment of the dock is a Rocket oil separator, which has been installed at the inner end for separating any mixture of oil and water which may be pumped out of the dock. It is capable of dealing with 50 tons of oily water per hour, and is so effective that the separated water can be discharged to sea with every confidence that the purity required by the recent "Oil in Navigable Waters Act" is attained. This apparatus is one of Messrs. Palmer's specialities. Access to the site is obtainable either by road or rail, a siding having been made to connect with the Great Western system.

(To be continued.)

METALLURGY AT THE BRITISH EMPIRE EXHIBITION.—I.

VISITORS to the metallurgical section of industrial exhibitions held in former years on the Continent—we need not in this connection name any particular locality or country—have always been struck with the very prominent place occupied by Vulcan and other mythological personalities in the decorative work distributed among the exhibits. These deities of a bygone age, who, it may be said in passing, are not the exclusive property of any particular nationality, were generally surrounded by numbers of big-headed and heavy-bearded gnomes occupied in the various processes of coal-getting, foundry work, or in lubricating some unseen piece of machinery with an oil can of distinctly modern form. We have always attributed this recourse for "decorative" purposes to myths of past centuries to the lack of real, national metallurgical pioneers. So far as we can remember we have never in this country decorated our provincial or metropolitan industrial displays with any representation of the twelve labours of Hercules or of those of any of that deity's numerous contemporaries. The English-speaking race gave birth to the men who actually carried out the pioneer work as far as metallurgy is concerned; we might have depicted these men in some form or other, but we are not aware that we ever did so. Their names are well known. They are, to mention only a few, Dud Dudley, who as early as from 1620 carried out with success the smelting of iron with pit coal, thus putting out of blast the wood and charcoal "bloomeries" which were at that time distributed over numerous forest-covered districts of England. Then came Darby, of Coalbrookdale, who first used coke in the blast furnace, in 1750, followed ten years later by Smeaton, of the Carron Ironworks, Falkirk. Before the close of the seventeenth century, Savery patented his steam engine for pumping the water out of the mines, an engine which was improved a few years later by Newcomen, other improvements being due to James Watt and, as regards construction, to John Wilkinson. The latter put down a steam-driven forge for the manufacture of wrought-iron in 1784. To Henry Cort is due the invention, in 1783, of the puddling furnace. Among the more recent pioneers may be mentioned Bessemer, followed by Thomas and Gilchrist, to whose inventive genius is due the development in steel manufacture in practically every country of the globe, starting from comparatively poor material of a class which our forefathers were compelled to assign to the slag heap.

The metallurgical displays at the British Empire Exhibition afford evidence that the work of these and other early British pioneers is being continued and enlarged in its scope. The exhibits illustrate every phase of manufacture from the pig iron to intricate forgings, castings and rolled products of every conceivable section. They further include specimens of the most modern alloys, whose properties are due both to actual manufacture in the liquid state and to subsequent treatment. In regard particularly to these latter alloys, we should like to remark here that when any one is mentioned in certain circles, stainless steel for example, there are always to be found metallurgical chemists who will say that they made in their own laboratory exactly the same metal some fifteen or twenty years ago, as the case may be. This is no doubt true, but their experience will be found, in going further into the subject to resolve itself generally into an accidental occurrence in the shape of a button remaining in a small experimental crucible. Such is not the case at the exhibition; all the special alloys displayed are samples of actual commercial, every day manufacture.

The different metallurgical exhibits are difficult to arrange for descriptive purposes according to their category, there being generally some of each class or kind at the stands of different works. The number and diversity preclude us from referring to them singly and in detail. We propose, therefore, to mention a selection only in this and in following articles, under the names of the various firms who have displayed them. Many of the metallurgical firms have added to their specialities the design and construction of pieces of machinery, several of which are also shown, and we shall at the same time call the attention of our readers to these particular exhibits.

Messrs. Edgar Allen and Company, Limited, Sheffield, whose works and products we described in detail in former issues, (ENGINEERING, August 19 to September 2, 1921), display a few representative specimens of their special trackwork built up of Imperial patent rolled maganese steel rails, the advantage of which is their exceptional long life compared with that of ordinary steel rails. Diagrams and photographs illustrate the quality and the complicated junctions, points, switches, crossings and complete lay-outs of their manganese steel special tramway trackwork. Further particulars concerning these other products are given in our articles above referred to. Examples of the work carried out in Messrs. Allen's Small Tools Department comprise a large selection of twist drills made from their "Stag" high-speed steel, cutters, reamers, lathe and other tools, files and hot and cold saws. Their Steel Department manufactures, among its numerous specialities constructional alloy steels for motor-cars and aircraft, and displays a number of selected lengths of steel showing the features by which their quality can be judged; they are contained in a rack, and each can be viewed separately. Castings made of toughened steel illustrate some of the specialities of their Steel Foundry Department. Other exhibits include shoes and dies for stamp batteries, mining drill steels and forged steel balls for ball mills. The railing round their stand is made entirely of "Imperial" stainless steel. The products of Messrs. Edgar Allen's Engineering Department take up the greater part of the space available at the stand, and include a portable "Stag" ore crusher 12 in. by 9 in. with revolving screen for crushing hard ore or stone down to approximately 1 in. cube; a set of "Stag" ore crushing rolls of the high-speed type, 18 in. diameter and 12 in. face, the shells being of specially heat-treated chrome steel; a "Stag" ball mill, size No. 1, of the continuous feed and discharge type; a "Stag" pulverising cylinder or intermittent ball mill, size No. 2, used for batch grinding of ores and minerals in either a wet or dry state; and a full size model of a dustproof automatic measurer for coal, sand, lime, or other material.

Messrs. Thomas Firth and Sons, Limited, Sheffield, have an admirable display of their stainless steel, many items in which will be found of great interest by engineers. The exhibit includes a remarkable selection of several different types of turbine blading, a particularly interesting specimen being an actual section from a 2,000 kw. Westinghouse turbine, the steam pressure in which was 200 lb. and the superheat 200 deg. F. The section shows 12 blades. The blades marked 1, 2 and 3 are of 5 per cent. nickel steel, they were inserted on June 11, 1920, the actual hours run being 12,809. Those marked 4, 5 and 6 are of Firth stainless steel and were inserted on the same day. The blades marked 7 to 12 are of 5 per cent. nickel steel, they were inserted in August, 1916, and have run for 29,989 hours. As will be noted, the nickel steel blades which were inserted in 1920 bear very marked signs of erosion, being very rough and pitted; the edges show distinct signs of fraying, a glance sufficing to realise the loss of efficiency which those worn blades would cause. The nickel steel blades inserted in 1916 are worn out. On the other hand, the stainless steel blades are as new and bright as on the day there were inserted; the edges have retained their initial sharpness, no signs of wear being apparent anywhere. This exhibit which gives striking evidence in favour of the use of Firth stainless steel for turbine blading, will greatly appeal to all turbine engineers who visit Wembley. Other displays of stainless steel by the same firm which will prove no less interesting to visitors who belong to the engineering profession include the following: Steam valve diaphragms which have been in use for nine months in a $4\frac{1}{2}$-in. double beat regulating throttle and emergency valve, in the steam test shop of a well-known firm of steam valve specialists, who state that they consider the conditions of the diaphragms to be perfectly satisfactory. The valve in which they have been working is subjected to the most severe treatment possible. A valve and seat of Firth stainless steel and similar parts of brass are shown side by side as they were used in the steam traps on water calorifier exhausts. The stainless steel parts after 17 months' continuous working show no signs of corrosion or erosion and practically no wear; on the other hand, the brass valves and seats seldom have a life of more than nine months, by which time the edges of the seat and the valve stem under the head are eroded away. A pump rod of Firth stainless steel also shown has been in use in an ammoniacal liquor pump for about nine months. The total life of the common steel rods in similar service has never exceeded six months, and their wear is several times greater than that of the stainless steel rod, in which it is only $\frac{5}{64}$ in. The latter, moreover, has worn to a smooth and polished surface involving much less attention to packing, whereas the common steel rods are badly scored. The original valves and seatings of brass and gun-metal used in vacuum pumps drawing off aciduous vapours from sugar-refining machinery only last for three or four weeks;

the stainless steel seating shown has already lasted for 18 months' continuous working day and night, and the valve for 12 months, both being still good for further indefinite service. Engineers will find in Messrs. Firth's stand numerous other comparative exhibits of a similar nature, piston rods, impeller shafts, &c., pointing to the great advantages to be derived by the use of their stainless steel. Other articles contained in their display will interest a wide circle of visitors; these stainless steel articles include surgical and dental instruments, knives, shovels, &c. Their other exhibits include steel castings, high-speed steel bars, saws, files, tools, springs and stampings.

The central exhibit of Messrs. Bolckow, Vaughan and Company, Limited, Middlesbrough, is a stand containing steel specimens, on the top of which is the model $\frac{1}{36}$ full size of a blast furnace plant unit, showing the blast furnace with all the auxiliary appliances, including a skip charging apparatus, hot blast stoves, calcining kilns, overhead gantry and rolling stock. The stand below contains the complete range of sections standardised by the British Engineering Standards Association for flange, bull-head and tramway rails and fish plates, as well as a large selection of rail sections other than standard. An interesting feature is the very large variety of tramway rail sections, up to 116 lb. per yard, manufactured by the firm for numerous municipalities and companies both in the home country and in the Dominions and Colonies. The other rolled material includes specimens of every variety of structural and shipbuilding sections, the quality of all of which is illustrated by a number of examples of drastic torsional, bending and drift tests. The stand is bounded by four monoliths of Cleveland ironstone. Specimens are shown of pig-iron, ferro-manganese, spiegeleisen, together with others of ores, fluxes and fuel used in their production. A slag brick wall, vases and other work illustrate the possibilities in store for blast furnace slag. Two pressed steel sleepers complete with rail lengths, distance pieces and keys are representative of a contract executed by the firm for the Great Indian Peninsular Railway. The stand further contains samples of the company's coal, coke and bye-products, samples of granulated, crushed and tarred blast furnace slag, of raw and ground basic slag, of crude tar, benzol and a large number of derivatives. A structural steel erection, built of the firm's sections by their associated company, Messrs. Redpath, Brown and Company, Limited, serves to illustrate in a small way the structural work carried out by the latter company for Messrs. Peter Robinson, Oxford Circus; Messrs. Cox's Bank, Waterloo Place; the Shell Oil Company, Russell Square, &c., of which photographs are shown. Another associated company of Messrs. Bolckow, Vaughan, is the Darlington Rolling Mills Company, Limited, whose exhibits comprise numerous rolled sections, and include one of the latter company's patent steel colliery arches of channel section and horse-shoe shape, the use of which is extending in the mining districts of this country. Plain and corrugated black sheets and galvanised sheets are the products of the Eston Steel and Galvanising Company, Limited.

A very effective display is made by the British Mannesmann Tube Company, Limited, of Newport and Landore. It includes specimens of steel pipes and tubes, weldless or lapwelded, for every conceivable purpose. Among these may be mentioned a riveted joint on a pipe 38 in. bore and $1\frac{1}{4}$ in. thick, part of an order for the Tata hydro-electric power scheme. Types of special joints for oil installations are shown both for the driving pipes and for the pipe-lines. A portion of a pipe 25 ft. in length, the bore of which is 54 in. and the thickness $\frac{17}{32}$ in., taken from an order from the Manchester Corporation Water Department for a total length of 27 miles and of a total weight of 22,000 tons, is exhibited, as are also tube coils for condensing and refrigerating plant. Boiler tubes; standard water, gas and air spigot and faucet tubing; ordinary, rigid, welded, Perkins and hydraulic joints; various types of loose flange joints, double border joints; the Victaulic joint to stand practically any pressure or vacuum, are also to be found on the stand. The numerous applications to which steel tubing can be put are illustrated by a variety of derricks, ship deck pillars, boats davits, masts, bollards, electric tramway standards and traction poles, CO_2 bottles, gas containers, &c. The company have supplied to the Amusements Section a flag staff 126 ft. in height, the bottom portion of which is 90 ft. in one length, 12·5 in. outside diameter and $\frac{5}{16}$ in. thick.

Messrs. John Brown and Co., Limited, Sheffield, exhibit a section through one of their 10-ton ingots, showing the pipe to be confined entirely to the top of the head, the body of the ingot being remarkably clean. They also show a gear-wheel rim, 14 ft. 7 in. in diameter, hollow rolled of ordinary carbon steel. Other striking exhibits of the firm are specimens of the Davis one-piece steel railway wheel; which is illustrated in the annexed figure. The tyre and wheel centre are in one piece, but as a result of the process of manufacture by a centrifugal casting process, the manganese content of the steel is confined to the tread and flange, the plate centre and hub of the wheel being entirely of mild steel. After annealing the wheel and machining the tread and flange, the wheel undergoes a special heat treatment which makes the tread and

FIG. 1. DAVIS ONE-PIECE STEEL RAILWAY WHEEL.

flange tough, hard and resistant to wear, whilst the centre and hub become tough and ductile. The company have acquired from the United States owners the manufacturing rights in this country, and the wheels shown have been made at their Scunthorpe works. Attention should be paid to the various test specimens of similar wheels displayed on the stand. There are, further, selections of heavy laminated motor-vehicle springs, one being 6 ft. 11 in. long, in chrome-vanadium steel; railway springs, spiral springs, buffers, axles; special "Adamant" steel-grinding plates for wet and dry ball mills for cement grinding; alloy steels, gear steels, castings and stampings of alloy steels; Tee and channel rings for agricultural tractor wheels; high-speed tool steels; ball races; a steel roll for rolling silver. The company's shipbuilding activities are illustrated by models of H.M. battle cruiser Repulse and of H.M. light cruiser Ceres, and by photographs of other naval and mercantile ships built at their Clydebank shipyard.

The exhibits of Messrs. Brown, Bayley's Steel Works, Limited, Sheffield, are incorporated in the structure and decoration of their stand. The balustrades are made up entirely of railway laminated and coil springs, the panels consisting on one side of pony tram tyres and on the other of elliptic springs. At one entrance are machined locomotive axle columns crowned by a large laminated spring, the other entrance being through a large locomotive tyre. The display further contains tyres; boiler angle rings; carriage and wagon axle forgings; tramway axle forgings of "Impacta" steel, shown bent cold without any sign of fracture; bars, test pieces, sections, &c. Most of the steel for the above is made in open-hearth furnaces. A few of the tool steels, particularly the high-speed tungsten steels, are manufactured by the crucible process, whilst the stainless steels are made in the electric furnace. A heat-treated, alloy steel, back-axle shaft shown is rolled and reeled to such fine limits of size and straightness that it can be put into service without any further machining beyond fitting the ends for attachment to the gear and hubs. Tests on this steel show a maximum stress between 50 and 70 tons per square inch. This will interest motor-car manufacturers, as also will the ball-bearing steels and case-hardening steels. The company's "Long strand" mild steel, also exhibited, is specially suitable for boiler staybolts. Among the most interesting products shown by the company are those of stainless steel, including pump rods, steam piston rods, hydraulic rams, hydraulic valves, steam valves and steam traps, almost all of which have been in actual service alongside exactly similar articles made of mild steel, brass and bronze; the relative value of these older materials as compared with stainless steel can be ascertained by the surface condition and the recorded wear. The exhibits include a Johnson hardness-testing machine made by the company; this is portable and cheap variant of the Brinell machine. The standard 10 mm. ball and 3,000 kilogramme load are used; the whole machine can be lifted and carried by one man and is claimed to be more simple in its operation than the standard fluid-pressure machine.

The Consett Iron Company, Limited, Consett, display a section of a silica brick retort, 24 in. by 18 in.; special silica bricks and the ganister they are made from; silica coke-oven shaped bricks; "delves" and other fire bricks, with the fire-clay used in their manufacture. There are specimens showing the company's various grades of hematite pig iron; bends and twists in steel bars, illustrating the high quality of the metal; sections of joists and rails; shipbuilding, bridge and boiler sections; chequered plates, &c. Another interesting specimen is a piece of the original plate forming part of the steamship Eton, removed after a collision, bent over several times and showing no sign of cracks. There are, further, samples of coal, bee-hive and by-product coke and representative exhibits of by-products.

THE ENGINEERS' CLUB.—The first annual dinner of the Engineers' Club was held on Tuesday, May 6, at the Connaught Rooms, the club premises being inadequate for the accommodation of the members and guests, numbering nearly four hundred, who were present at the function. The chair was taken by Mr. Ben H. Morgan, the Chairman of the British Empire Producers' Organisation, and of the General Committee of the Club, as Sir Joseph Isherwood, the President, had been called abroad at short notice. Among the guests were Mr. W. H. Patchell, Mr. Frank Hodges, M.P., Civil Lord of the Admiralty; Sir T. Harris Spencer, Sir Malcolm McAlpine, Engineer Vice-Admiral Sir Robert Dixon, Mr. H. B. Burford, Brig.-General Sir William Horwood, Sir Harry Brittain, Sir Hugh Denison and many other gentlemen holding distinguished positions in engineering or political life. In responding to the toast of "British Engineering," which had been proposed by Sir T. Harris Spencer, Mr. W. H. Patchell said that propaganda was needed to enlighten both employers and employed as to the true condition of industry. Unrest was bound to occur when a skilled mechanic could earn nothing like as good wages as a labourer employed for cleaning the streets, and this real injustice must be removed. The taxation per head of population was now 16*l.* per annum, as compared with 3*l.* 11*s.* 0*d.* before the war, and only by industrial peace and hard work could the country go on. He had much sympathy with Mr. E. W. Petter's scheme for free discussion between employers and employed as to the returns of manufacturing concerns, but there was danger in the publication of facts and figures which would assist foreign competitors. Mr. Frank Hodges emphasised the importance of science and said that the true function of the politician was to give effect to the conclusions of scientific men. Most of the other speeches left no doubt as to the feeling of the club on the question of the protection of British industry. In responding on behalf of the Engineers' Club, Mr. Ben H. Morgan mentioned that in two and a-half years it had grown to a membership of 3,150, thanks largely to the organising ability of Mr. E. L. Hill, the Hon. Secretary.

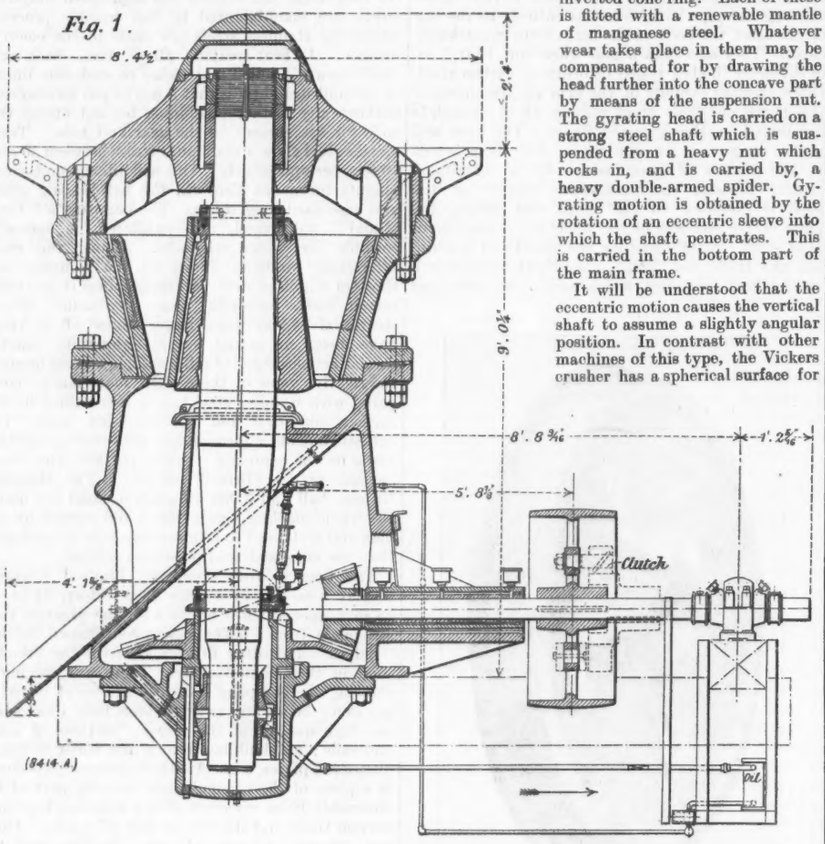
VICKERS' GYRATORY CRUSHER AT THE BRITISH EMPIRE EXHIBITION.

THE gyratory crusher shown in the accompanying Figs. 1 and 2 was designed by Messrs. Vickers, Limited, of Barrow-in-Furness, to meet the demands for a strong and durable machine capable of crushing large quantities of rock, ore and the stone used for road metal, railway ballast, and in concrete. In the machine pieces of stone as large as 3 ft. 6 in. by 1 ft. can be broken up until their greatest dimension is not more than 3 in., at the rate of 75 tons to 100 tons per hour, depending upon the nature of the material. In the process the average power required is about 80 horse-power.

Feeding is arranged on two sides of the machine through a large hopper. From here the stone passes into the space between a gyrating coned head and an inverted cone ring. Each of these is fitted with a renewable mantle of manganese steel. Whatever wear takes place in them may be compensated for by drawing the head further into the concave part by means of the suspension nut. The gyrating head is carried on a strong steel shaft which is suspended from a heavy nut which rocks in, and is carried by, a heavy double-armed spider. Gyrating motion is obtained by the rotation of an eccentric sleeve into which the shaft penetrates. This is carried in the bottom part of the main frame.

It will be understood that the eccentric motion causes the vertical shaft to assume a slightly angular position. In contrast with other machines of this type, the Vickers crusher has a spherical surface for the outside of the sleeve on the shaft, and this part fits into a corresponding spherical recess in the eccentric. Alignment of the shaft and the eccentric sleeve bearing is thus provided for, and the great strains on the shaft and sleeve bearing which would have been produced if the outside of the sleeve had been parallel, are therefore completely avoided. Efficient lubrication of the eccentric sleeve and the ball and socket bearing is imperative, and this is obtained by the installation of a small rotary pump driven off the crusher countershaft. By it the level of oil is maintained above the working parts and therefore all the running system is submerged in an oil bath from which the overflow goes through a filter before it is passed to the pump to be returned. Packed collars provide ample protection for the working parts, from the intrusion of any dust produced as the stone is crushed.

Fig. 1.



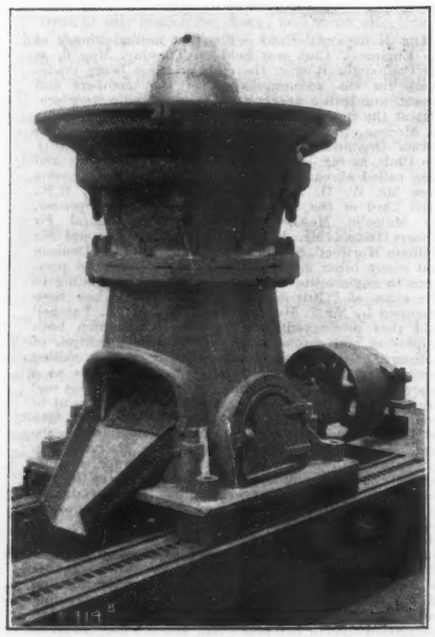


FIG. 2.

THE WILSON PROJECTION COMPARATOR FOR SCREW THREADS.

ONE of the many interesting instruments included in the equipment of the research laboratory which forms an important feature of Messrs. Vickers' exhibit at the British Empire Exhibition, and is referred to elsewhere in this issue, is an instrument known as the Wilson projection comparator. This instrument, which we now propose to describe, was devised by Messrs. R.P. Wilson and A. G. Cooke, during the war, for gauging screw threads and other similar solids of revolution. Messrs. A. Hilger Limited, 75A, Camden Road, N.W.1, are the makers of and sole licensees for the instrument, which is not intended for measuring gauges but for actual repetition gauging work, although it can well be employed for checking working gauges where the highest degree of accuracy is not essential; errors of the order of 0·001 in. are readily determined by its aid. For repetition gauging, it has the advantage of great rapidity in working, it being possible to gauge as many as 700 pieces per hour on one instrument; practically the same output, we may mention, is also obtainable in gauging between plus and minus limits.

The instrument depends for its action upon the fact that, in the case of any screw with a single-lead thread the roots and crests of which are either both flat or both curved to the same radius, the parts at the opposite ends of a diameter are exactly complementary. If, then, separate images of the two sides of a screw are projected on to a screen and at the same time are interchanged laterally so that the right-hand side of the screw appears on the left-hand of the screen and *vice versa*, the threaded parts of the two images can be brought together so that they fit exactly one into the other without overlapping and without leaving any intervening space. When this has been done for a screw of any particular diameter, the screw with which the optical adjustments were made can be replaced by another, and if the latter is of precisely the same effective diameter, the two images will again coincide exactly. If, however, the second screw is slightly larger or smaller than the first, the images will either overlap or will fail to come into contact with each other, the two conditions being indicated, respectively, by the presence of a dark or light wavy line between the two images.

Fig. 1, opposite, is a photographic illustration showing the appearance of the instrument complete, except for the screen on to which the images are projected, and Figs. 2 and 3 are a plan and elevation, respectively, showing the construction and arrangement of the essential parts. Fig. 4 is a diagram illustrating the optical principles employed. Referring first to Fig. 1, it will be seen that a heavy base, supported on three feet, carries four adjustable pedestal holders on which the optical parts are mounted. The holder on the left of Fig. 1 carries a source of light, which is usually a Pointolite lamp enclosed in a lantern. The lamp is located at the principal focus of a condensing lens which is carried by the adjacent holder and forms a parallel beam of light in which the screw to be projected is located in the third holder. The fourth holder, that on the right of Fig. 1, carries the projecting system, which is of a particularly interesting character, and to follow its design and construction reference should be made to Figs. 2, 3 and 5, as well as to Fig. 1.

As indicated by the dotted lines in Fig. 2, and also in the diagram, Fig. 4, there are two separate achromatic projecting lenses, of each of which nearly a half is cut away, so that the optical centres of the two lenses can be brought close together. The lenses are moved laterally by means of the micrometer drums most clearly shown in Fig. 5, and the drums are generally adjusted so that the distance between the optical centres of the lenses is equal to the effective diameter of the screw to be tested. The drums, we may mention, are graduated so that when each is set to read the known effective diameter of the screw the lenses will be at the required distance apart. The lateral transposition of the images of the opposite sides of the screw formed by the two lenses is effected by means of two reflecting prisms indicated in Fig. 4, and also shown near the centre of Fig. 5. They are carried on mounts which can be swung aside to facilitate the preliminary focussing of the images on the screen and are also provided with screws so that the prisms can be tilted in the vertical plane to bring the images into accurate parallelism; other screws enable the prisms to be rotated slightly about vertical axes to adjust the lateral deviation of the beams of light forming the images; this adjustment, of course, is used to bring the images of the opposite threads of an accurate screw into exact engagement as explained above. We may here point out that, since the two lenses are located symmetrically relatively to the screw to be projected, the images of the two parts of the thread are formed by similar parts of the respective lenses. From this it follows that the inevitable slight distortion of the image projected by each lens is exactly balanced by the corresponding distortion due to the other lens; the two distortions thus neutralise each other.

In practice, an accurate screw is prepared for use as a standard with which the subsequently manufactured screws are to conform. It should be noted, however, that since the standard is only required for optical comparison, and is not, therefore subjected to wear, there is no necessity for hardening it, and one of the chief difficulties of producing a standard is, therefore, eliminated. The third holder, in which the standard screw is placed as shown in Fig. 1, has a hole bored and reamed to a No. 1 Morse taper and the standard may, therefore, be cut on the end of the corresponding Morse taper blank, although other methods of locating it can, of course, be arranged for. With the standard screw in position, and the transposing prisms swung aside, the two images of the threads are accurately focussed on to a white screen placed in any convenient position a few feet from the instrument, the two projecting lenses having been previously set to the correct distance apart by means of the micrometer drums. When this has been done, the prisms are replaced and

THE WILSON PROJECTION COMPARATOR AT THE BRITISH EMPIRE EXHIBITION

CONSTRUCTED BY MESSRS. A. HILGER, LIMITED, LONDON.

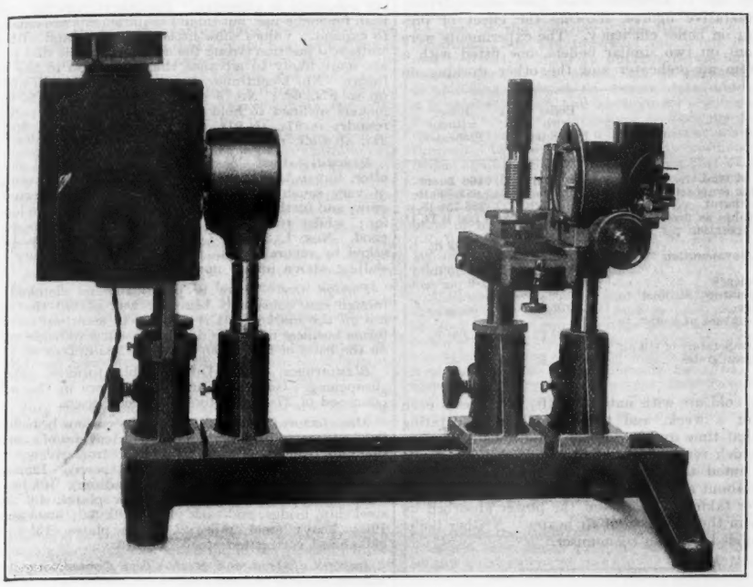


FIG. 1.

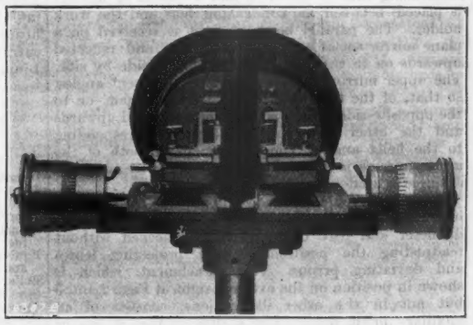


FIG. 5.

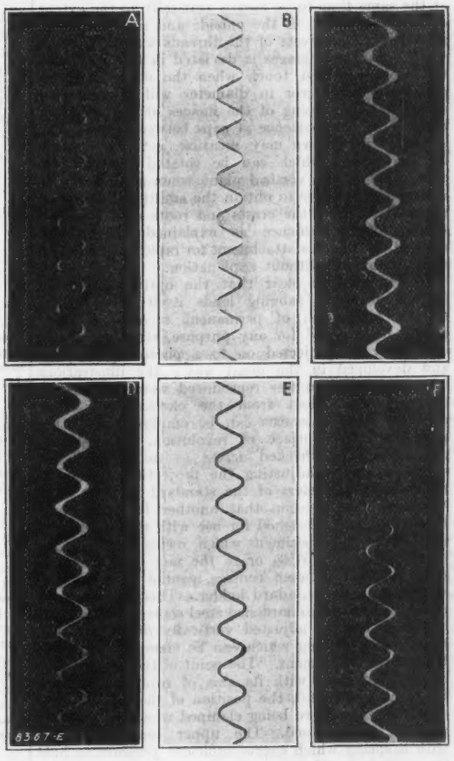


FIG. 6.

Fig. 2.

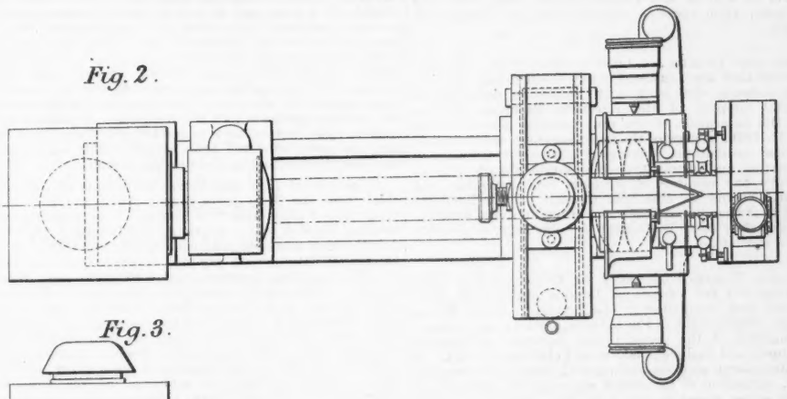


Fig. 3.

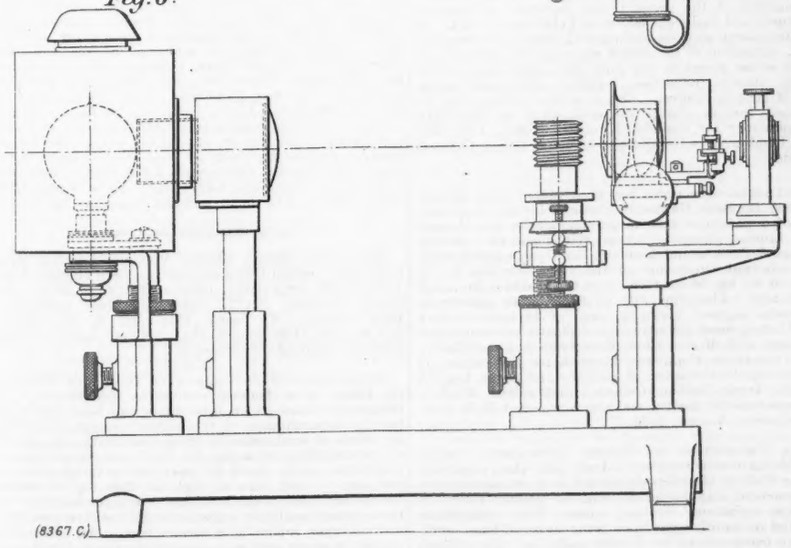
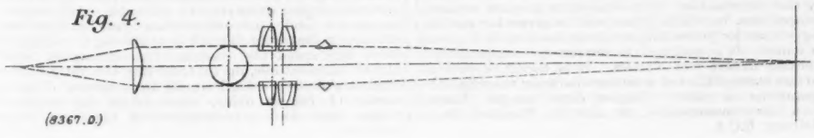


Fig. 4.



adjusted to bring the two images of the thread into contact without overlapping, the apparatus then being ready for use. For repetition gauging, the standard screw is replaced by a simple form of jig on which the screws to be checked are placed in succession, and any error in diameter can easily be detected by glancing at the images on the screen.

The forms that the screen images take with screws of different characteristics are shown in Fig. 6, of which the portion lettered A shows the result obtained with a screw of correct effective diameter. The portions lettered C and E show, respectively, the images obtained with screws of uniformly low and high effective diameters, while the portions lettered D and F show the effects produced by screws having slight tapers. In the figure lettered D, the diameter is too low throughout, but in that lettered F the diameter of the upper part is too high while that of the lower part is too low. The result shown by the portion of Fig. 6 lettered B, was obtained with the instrument set for checking the depth of the threads, instead of the effective diameter, the accuracy of the thread depth being indicated by the fact that the roots and crests are in exact coincidence. It will be noticed that, in this case, the flank outlines are rather heavy, but this is due to interference caused

by the helix angle of the thread. To obviate this effect in high-class work, such, for instance, as the quantity production of best quality taps, a special attachment is provided which enables the best possible definition to be obtained. With this attachment, the lamp and condensing lens are lowered, and a system of mirrors is placed between the condensing lens and the work holder. The parallel beam of light is received on a plane mirror set at an angle of 45 degs, and reflected upwards on to two plane mirrors placed side by side. The upper mirrors are set at slightly different angles, so that, of the two beams reflected from them on to the opposite sides of the screw, one is inclined upwards and the other downwards at angles corresponding to the helix angle. The adjustment of both of the upper mirrors is effected simultaneously by means of a single geared micrometer screw.

Another attachment is now embodied in the standard instrument to enable outside diameter, effective diameter and core diameter to be checked without readjusting the positions of the projecting lenses and deviating prisms. This attachment, which is shown in position on the extreme right of Figs. 2 and 3 but not in the other illustrations, consists of an auxiliary prism mounted in a slide so that it can be placed in front of either of the main deviating prisms to enable one of the images to be shifted laterally by an amount equal to the depth of the thread and at the same time to be moved vertically to the extent of half the pitch. If the outside and core diameters are correct, the crests of the threads will just touch when one of the images is deviated in this way, and the roots will just touch when the other image is deviated. Any error in diameter will be indicated either by overlapping of the images at the crests or roots or by the existence of gaps between them. The auxiliary prism, we may mention, actually consists of two prisms which can be rotated relatively to each other in the vertical plane when setting up the instrument in order to obtain the additional deviation required to bring the crests and roots of a standard screw into coincidence as explained above. The method of using the attachment for rapid limit gauging will be obvious without explanation.

It will also be clear that the optical projection system of screw gauging lends itself very readily to the production of permanent records, if these should be required for any purpose, since the image can easily be projected on to a photographic plate and developed in the usual way; the illustrations from which Fig. 6 was reproduced were prepared in this manner. Apart from the checking of screw elements, the apparatus can be employed for other purposes. Any surface of revolution, for instance, can readily be checked across as many diameters as necessary by adjusting the projection system to the various diameters of the standard in their turn. We may also mention that another form of work-holder has been designed for use with the instrument in order to hold specimens which, owing to the length of the screwed portion or to the fact that they can only be fixed between centres, cannot be held conveniently in the standard holder. This class of work is held between two hardened steel centres, the mounts of which can be adjusted vertically on a steel rod fixed into a casting which can be clamped on to the base of the instrument. The point of the lower centre is not coincident with its axis of rotation, so that, by turning it round, the position of the work can be adjusted, the centre being clamped when the required position is obtained. The upper centre is fitted with a spring which exerts sufficient pressure to hold the work in position.

The standard instrument will deal with screws, or other solids of revolution, ranging from ¼ in. to 2 ins. in diameter, and the length of the part of which enlarged images are projected on the screen is 1¾ in.; any irregularities which may exist in the whole of this part can thus be seen at a glance. Finally, it may be mentioned that the instrument provides the only known method of checking tapered screws other than by laborious point by point measurement.

STANDARD NOMENCLATURE FOR CYCLE AND MOTOR-CYCLE PARTS.—The British Engineering Standards Association have recently issued a report on the British standard nomenclature for cycle and motor-cycle parts. The report, which is numbered 5012–1924, forms division xix to xxiii of a complete report on automobile, motor-cycle and cycle nomenclature, of which two parts relating to automobile parts and accessories and automobile coachwork have already been issued. The new publication covers all the parts used in the construction of pedal bicycles, tricycles, carrier tricycles and motor cycles, but a considerable portion of it relates to the cylinders, valves, pistons, timing gear, ignition systems and other details of motor-cycle engines. This will doubtless be found useful in the workshop and garage, as well as in connection with the preparation of manufacturers' catalogues and stock lists. Copies can be obtained (1*s.* 2*d.*) through the usual channels, or direct from the Association, 28, Victoria-street, London, S.W.1.

BOILER EFFICIENCY WITH PRE-HEATED AIR.

IN the course of his recent paper on "Water Tube Boilers," read before the Junior Institution of Engineers, Mr. L. Marshall Jockel gave some interesting comparative figures, showing the effect of pre-heated air on boiler efficiency. The experiments were carried out on two similar boilers, one fitted with a Ljungström air-preheater and the other working on ordinary cold air with natural draft. The tests each lasted for a week, and the boilers were operating during that time under ordinary conditions of service, a fact which renders the results more significant. It will be noted that the effect of the pre-heater was to bring about a saving of about 13·6 per cent. in the fuel, after taking into account the power absorbed by the fans in the Ljungström air heater. Neither boiler was provided with an economiser.

—	Boiler with Preheater.	Boiler without Preheater.
Duration of trial	168 hours	168 hours
Total water evaporated	2,300,240 lb.	1,853,700 lb.
Total coal burnt	306,656 lb.	288,736 lb.
Calorific value, as fired	11,000 B.Th.U.	11,000 B.Th.U.
Actual evaporation per lb. of fuel	7·50 lb.	6·42 lb.
Equivalent evaporation "from and at"	9·0 lb.	7·70 lb.
Boiler efficiency	79·4 per cent.	67·9 per cent.
Gas temperature at inlet to preheater	610° F.	—
Gas temperature at outlet to flue	250° F.	565° F.
Average temperature of hot air below chain grates	455° F.	—

INSTITUTION OF MUNICIPAL AND COUNTY ENGINEERS.—The Irish district meetings of this Institution are to be held in Belfast and Dublin on the 15th, 16th and 17th inst., when visits to various places of interest will be paid.

CITY AND GUILDS OF LONDON INSTITUTE.—We are informed that the London County Council has come to the conclusion that it will be unable to continue its financial support of the Finsbury Technical College after the expiration of the quinquennial period ending July 31, 1926, in view of the fact that there are a number of other institutions making provision for training in engineering and chemistry, which could absorb without difficulty the number of students now attending the college. Owing to this, the Council of the Institute states that there is no other course but to make arrangements to close down the college in July, 1926, or possibly before that date.

WATER POWER RESOURCES OF CANADA.—The High Commissioner for Canada in London states that there has just been completed in the Dominion Water Power Branch, Department of the Interior, Ottawa, an interesting analysis of the water power resources of Canada, developed and undeveloped, as at February 1, 1924. It includes special sections dealing with progress in development, utilisation of developed water power, and on the use of water power in the pulp and paper and central electric station industries, together with much other data of general interest. Copies of the bulletin may be obtained free of charge on application to the High Commissioner for Canada, Kinnaird House, Pall Mall East, London, or to the Director of Water Power, Ottawa, Canada.

CONTRACTS.—An order has been placed with Messrs. Vickers, Limited, Barrow-in-Furness, for the construction of a passenger and cargo steamer by the Warren Line, Limited (Messrs. Furness, Withy and Co.), for the Liverpool–Canada and Newfoundland passenger service. The principal dimensions of the vessel are 405 ft. by 54 ft. 6 in. by 34 ft. 4 in., and the deadweight about 7,030 tons. The ship will be fitted with quadruple-expansion engines, giving a speed of 14 knots loaded. The Underground Company have placed two important contracts with Messrs. Chas. Brand and Son and Messrs. The Foundation Company, Limited, for the driving of tunnels on the extension of the City and South London Railway from Clapham Common to Morden. Work is to commence forthwith, and the new line will be completed about August, 1925.

THE PREVENTION OF MINING ACCIDENTS. PRIZES FOR WORKMEN INVENTORS.—Last year the proprietors of the *Colliery Guardian* instituted a novel competition for practical suggestions tending to greater safety in haulage operations in coal mines. This competition resulted in useful suggestions being received from workmen in every one of the British coalfields. Encouraged by this success, they have decided to promote a second competition, in which prizes will be given for the best suggestions for preventing accidents due to falls of ground in mines. It is proposed to restrict the competition to working miners and officials. It is hoped to promote further competitions of a similar character covering other operations in mines. Further data can be obtained from our contemporary, 30 and 31, Furnival Street, Holborn, E.C.4.

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

The Cleveland Iron Market.—A fair number of inquiries for Cleveland pig-iron are reported, but actual sales are not numerous or extensive. Demand is more for export than for home use, but inland requirements are expected to expand. Values show little movement, and with the statistical position strong the opinion prevails that prices are more likely to advance than otherwise in the near future. No. 1 continues very scarce, and is still quoted up to 97*s.* 6*d.*; No. 3 g.m.b. is quite 92*s.* with some makers inclined to hold out for up to 92*s.* 6*d.*; No. 4 foundry is 91*s.* to 91*s.* 6*d.*; and No. 4 forge, 90*s.* to 91*s.* all f.o.t. makers works, and f.o.b. Tees.

Hematite.—East Coast hematite is fairly well sought after, but in this branch also inquiries are not resulting in very much business. Local needs are expected to grow, and further sales to the Sheffield district are looked for; whilst trade with the Continent promises to be good. Nos. 1, 2, and 3 are quite 99*s.*, and 99*s.* 6*d.* is asked by several firms. No. 1 is put at sixpence to a shilling above mixed numbers.

Foreign Ore.—There is practically no demand for foreign ore, consumers being so well placed that they are off the market. It is difficult to ascertain on what terms business might be done, but sellers indicate values on the basis of best rubio at 23*s.* 6*d.* c.i.f. Tees.

Blastfurnace Coke.—Durham blastfurnace coke is cheapening. Good medium qualities are in the neighbourhood of 27*s.* 6*d.* delivered to local users.

Manufactured Iron and Steel.—The various branches of finished iron and steel present no new features of moment. Common iron bars are 12*l.* 10*s.*; iron rivets, 14*l.*; packing (parallel), 9*l.*; packing (tapered), 12*l.*, steel billets (soft), 9*l.*; steel billets (medium), 10*l.*; steel billets (hard), 10*l.* 5*s.*; steel boiler plates, 13*l.* 10*s.*; steel ship, bridge, and tank plates, 10*l.* 5*s.*; steel angles, 10*l.*; heavy steel rails, 9*l.*; fish plates, 13*l.*; and galvanised corrugated steels, 17*l.* 10*s.*

Imports of Iron and Steel.—Tees Conservancy Commissioners returns, issued this week, of the imports of the Tees from Holland, Belgium, France, Norway, Germany, Sweden, and coastwise for the six months ending April 30 last, together with the statistics for the same six months of a year ago, as well as for the corresponding pre-war period of 1913–1914 give the imports of pig-iron for the months just ended at 13,707 tons, against 4,125 tons a year ago, and 106 tons in the pre-war period; whilst crude steels, bars, billets, blooms and slabs unloaded to the end of last month are shown at 36,972 tons, against 40,365 tons a year ago, and 24,134 tons in the pre-war period; and the quantities of plates, bars, angles, rails, sheets, and joints brought into April 30 last are given at 8,286 tons against 6,349 tons a year ago, and 13,460 tons in the pre-war period.

Shipments of Iron and Steel.—Shipments of iron and steel from the Tees ports during April, together with 8,422 tons of pig-iron sent to Scotland from Skinningrove, totalled 104,606 tons, comprising 48,238 tons of pig-iron, 4,289 tons of manufactured iron, and 52,079 tons of steel. Of the 39,816 tons of pig-iron shipped from the Tees 31,256 tons went overseas, and 8,560 tons went coastwise; of the manufactured iron despatched 3,779 tons went abroad, and 510 tons went coastwise; and of the steel cleared 43,424 tons went to foreign parts, and 8,655 tons went coastwise. The April overseas shipments of pig-iron were the largest for twelve months past. Germany was the largest receiver of pig iron taking 8,301 tons; whilst Scotland, in addition to supplies from Skinningrove took 5,570 tons; Belgium was a customer for 5,275 tons; France received 5,104 tons; Denmark 3,573 tons; Sweden, 2,710 tons; Italy 2,685 tons; and Wales 2,580 tons. Again, India was by far the largest customer for both manufactured iron and steel, receiving 1,683 tons of the former, and 22,711 tons of the latter. Other principle importers of steel were: Japan 1,851 tons; the Straits Settlement 1,838 tons; Germany 1,397 tons; Denmark 1,297 tons; Hong Kong 1,292 tons; Natal 1,232 tons; and the Argentine 1,231 tons.

PERSONAL.—British Electric Vehicles, Limited, state that their London Office address has been changed from 1, Queen Victoria-street, London, E.C.4, to 36–37, Old Jewry, London, E.C.2. Their telephone number is 6333 Central.—We learn that Mr. S. H. March, M.I.Mech.E., has joined the staff of Messrs. Alfred Herbert, Limited, of Coventry.

DETERMINATION OF CARBON IN IRON AND STEEL.—On behalf of a chemical committee appointed by the German ironmasters to investigate the best conditions for the determination of the carbon percentage in steel by means of combustion in oxygen, as commonly carried out in metallurgical works, Dr. H. J. van Royen reports (*Stahl und Eisen*, April 10 last) that a temperature of 900 deg. C. and even as high as 1000 deg. C. is not always sufficient in this analysis. It was observed that the oxidised residue of a first test might still be proved to contain some carbon in a second test. The addition of oxidising agents such as lead peroxide, bismuth tetroxide or merely copper oxide is often advisable. Whilst ferro-manganese and ferromolybdenum can be completely oxidised in the test in 15 minutes at 900 deg C., manganese steel, high speed tool steel and ferro chromium require higher temperatures, up to 1,200 deg. C. When carbon steels are to be oxidised simply in a current of air by means of copper oxide, three times the weight of copper oxide and a temperature of 1,200 deg. C. are required.

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

Iron and Steel.—Traffic returns indicate progressive revival in the steel and engineering trades, taken as a whole. Compared with pre-war, the total tonnage in semi-finished manufactures, machinery and steel products going to inland users and to the ports, is something like 50 per cent. larger. So greatly has the basis of production been extended, however, that a much heavier volume of contracts is required in order to ensure anything like regular activity. The market for raw and semi-finished materials seems to be more or less marking time, pending price developments. The one exception is bar iron, which at an average of 12*l.* 10*s.* per ton from South Yorkshire mills, is in strong request by wagon builders. Transactions in forge and foundry pig iron continue only moderate, though a fair tonnage of hematites is going into consumption in connection with steel output in the constructional trades. The outlook in crude steel manufacture is somewhat overshadowed by wage disputes, and by indications of the likely advent of a recurrence of Continental competition. Most of the big plants in the South Yorkshire district are utilising the bulk of their production facilities, though new business shows a tendency to fall away. Purchases of scrap metals are restricted to the smallest limits consistent with immediate requirements. Official quotations rule as follow:—Hard basic steel billets, 10*l.* per ton; soft basic steel billets, 9*l.*; West Coast hematites, 6*l.*; East Coast hematites, 5*l.* 5*s.*; Lincolnshire No. 3 foundry, 4*l.* 16*s.*; Lincolnshire forge, 4*l.* 14*s.*; Derbyshire No. 3 foundry, 4*l.* 15*s.*; Derbyshire forge, 4*l.* 12*s.* 6*d.*, bars, 12*l.* 10*s.*, sheets, 15*l.* Makers of boilers are fairly well booked forward. Mining machinery is in growing request, and pit gear is on order in connection with colliery developments in the South Yorkshire and adjacent districts. The demand for various classes of tools has broadened considerably. Producers, while maintaining high quality, are incorporating the best features in the design and shape of competing articles.

South Yorkshire Coal Trade.—Conditions are gradually becoming more normal, an easing in the general demand having coincided with increased outputs. More industrial fuel is available now that supplies of this class have ceased to be diverted to the house coal market to supplement deficient deliveries. The export call for best steams is easier, but home requirements are still absorbing a heavy tonnage, and there is a fair market for cobbles, nuts and slacks. Purchases of house coal show a substantial reduction. London buyers are no longer willing to pay premiums on maximum quotations for special deliveries. Quotations:—Best branch handpicked, 36*s.* to 39*s.*; Barnsley best Silkstone, 34*s.* to 36*s.*; Derbyshire best brights, 31*s.* to 35*s.*; Derbyshire best house, 27*s.* to 29*s.*; Derbyshire best large nuts, 27*s.* to 28*s.*; Derbyshire best small nuts, 20*s.* 6*d.* to 23*s.*; Yorkshire hards, 27*s.* to 30*s.*; Derbyshire hards, 25*s.* to 28*s.*; rough slacks, 12*s.* 6*d.* to 15*s.* 6*d*; nutty slacks, 12*s.* to 14*s.*; smalls, 8*s.* to 10*s.*

NOTES FROM THE SOUTH-WEST.

CARDIFF, Wednesday.

The Coal Trade.—Quiet conditions again ruled in the South Wales coal markets last week, but there are signs that the bottom has been touched and that prices are likely to take an upward trend. Despite the apparent inactivity of the coal market chartering has been comparatively brisk, as exporters, in order to take advantage of the concessions obtainable from coal salesmen for prompt orders, have been fixing up single cargoes. Individually merchants have been quiet, but collectively quite a number of orders must have been placed for cargoes ranging from a few hundred tons to five and six thousand tons Another factor is that most of the collieries in the coalfield were idle on Monday for the usual May-day demonstrations. This resulted in a big loss in output, estimated at about 200,000 tons, and this reduction in production is bound to have some influence on prices. Again, the colliery salesmen have revised the group committees' practice under which salesmen of different classes of coal meet from week to week with a view to exchanging opinions on the conditions of the market concerning the class of coal represented by the conference and avoiding unnecessary competition. For best Admiralty large coal values have ranged between 27*s.* 6*d.* and 28*s.*, with Monmouthshires from 25*s.* to 27*s.* and drys from 26*s.* 6*d.* to 27*s.*, while smalls ruled from 14*s.* 6*d.* to 18*s.* 6*d.*, according to quality. With regard to coke furnace sorts prices ranged from 38*s.* to 39*s.* for export, with foundry from 42*s.* 6*d.* to 47*s.* 6*d.*, and special foundry from 57*s.* 6*d.* to 60*s.*

Iron and Steel.—Exports of iron and steel goods from the South Wales ports last week were considerably increased when compared with the preceeding week. Shipments amounted to 23,558 tons, against 7,696 tons, of which tinplates and terneplates totalled 8,666 tons, against 6,151 tons; blackplates and sheets 3,865 tons, against 515 tons; galvanised sheets 5,088 tons, against 974 tons; and other iron and steel goods 5,939 tons, against 56 tons. In connection with the last ascertainment of the average selling prices of tinplate bars, the Welsh steel makers have resolved to continue for a further three months the *ex-gratia* payment, which means that the steelworkers' wages will remain at 56¼ per cent., made up of 36¼ per cent. under the sliding scale, plus the *ex-gratia* payment of 20 per cent. to men with a base rate of 30*s.* per week and under, whilst the tinplate workers get 25 per cent. consolidated rate, together with 11¼ per cent. under the sliding scale and a further 7½ per cent. *ex-gratia* payment.

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Scottish Steel Trade.—Movement in the Scottish steel trade is still of a very restricted nature and buyers are showing little disposition to place contracts of any importance, and actual business is almost wholly confined to current requirements. The latter are not heavy because of the continued unsettlement of industrial conditions, but the prospects are more encouraging, and business is likely to improve before long. An increased demand for plates, &c., is expected from the shipbuilding yards at no distant date, but at present it is painfully small, and employment is suffering accordingly. Producers of structural sections are doing fairly well, and there is quite a lot of railway material going through. In the black sheet trade business is a turn better again this week, although not just as good as it was a month or two ago. The general export trade is not too satisfactory and a decided increase in the demand from overseas would be most welcome. Prices show little or no change, and are as follows:—Boiler plates, 13*l.* 10*s.* per ton; ship plates, 10*l.* 5*s.* per ton; sections, 10*l.* per ton; and sheets, $\frac{5}{16}$ in. to ½ in., 12*l.* 10*s.* per ton, all delivered Glasgow stations.

Malleable Iron Trade.—The demand for malleable-iron continues very poor, and makers who were fortunate to book a fairly good tonnage some time ago are now considered very lucky. The contracts on hand are just managing to keep plant moving, and every artery for fresh business is being diligently searched. As tube-makers are doing well at present, there is quite a good outlet for hoops and strips. The price of "Crown" bars keeps steady at 12*l.* 10*s.* per ton, delivered Glasgow stations.

Scottish Pig-iron Trade.—In the Scottish pig-iron trade very little change has taken place over the week, but quite a firm tone continues to prevail. The demand is small, but so also is the present output, and no change will be made in the latter until the former shows signs of expansion. Inquiries are a turn better, but there does not seem much prospect of business opening out to any great extent at present. Prices are firm and the following are the current market quotations:—Hematite, 5*l.* 2*s.* 6*d.* per ton, delivered at the steel works; foundry iron, No. 1, 5*l.* 5*s.* per ton; and No. 3, 5*l.* per ton, both on trucks at makers' yards.

Scottish Pig-iron Shipments.—The shipments of Scottish pig-iron from Glasgow Harbour for the week ending last Saturday, May 3, amounted to 2,754 tons. Of that total, 2,715 tons went overseas and only 39 tons coastwise. For the corresponding week of last year the figures were 762 tons foreign, and 100 tons coastwise, making a total shipment of 862 tons.

VANADIUM DEPOSITS.—Bulletin 212, recently published by the United States Department of the Interior, through the Bureau of Mines, states that the chief deposits of vanadium, by far the most important in the world, are at Minasragra, Peru, 20 miles from Cerro de Pasco. The main ore body is a lens-shaped mass about 30 ft. wide by 300 ft. to 400 ft. long; it contains several minerals, that constituting the larger part of the deposit being called "quisqueite." This mineral is a black carbonaceous substance, containing sulphur, but no vanadium. The vanadium lies mostly at the southern end of the ore body, and to a depth of 20 ft. is present as red calcium vanadate; this vanadate is brighter than that in Colorado and Utah, and it may carry as much as 50 per cent. of vanadium oxide. It occurs in small pockets and fills the cracks and fissures in the fine shale. Below is the mother lode, which carries as high as 10 per cent. vanadium oxide, and nearly as much sulphur. On the east and south sides of the mother lode is a hard blue-black vanadium shale carrying as much as 13 per cent. of vanadium oxide and 4 per cent. to 5 per cent. of sulphur. The main mineral is patronite, which is greenish black, and contains 19 per cent. to 24·8 per cent. vanadium oxide. In the United States the largest deposits are in San Miguel County, South Western Colorado. The mineral at that place is roscoelite, which is a vanadium mica. The vanadium, which is light to dull green and fine-grained, is found in a sandstone that occasionally carries splotches of carnotite, but the amount of uranium present is extremely small. The average ore mined has a content of from 1 per cent. to 2 per cent. of vanadium oxide. Vanadium ore has also been discovered in Huerfano County, Colo., near the Sangre de Cristo Range. The ore is heavy, black, and banded, and contains small quantities of uranium oxide. It shows 2 per cent. to 7 per cent. of vanadium oxide. In Eagle County, 7 miles south-east of the town of Eagle, a silver ore has been found carrying vanadium, but it is more or less local in character. Zinc descloizite has been found in limited quantities in Nevada, and cuprodescloizite exists in reasonable quantities in the Shattuck mine, at Bisbee, Ariz. Vanadanite, or lead vanadate, occurs in several places in the West, particularly in Arizona, New Mexico, Nevada, and California. This mineral is almost invariably found as a low-grade ore carrying from 0·1 per cent. to 0·6 per cent. of vanadium oxide, seldom in high grade pockets. The principal use of carnotite during the last few years has been in the production of radium. Ordinary carnotite ores carry from 3 per cent. to 6 per cent. of vanadium oxide, and the vanadium in the ore is recovered during extraction of radium. Some ores high in vanadium but low in uranium and radium have been treated primarily for vanadium, but this procedure is not usual. From 200,000 lb. to 300,000 lb. of vanadic oxide is produced annually in the extraction of radium.

NOTICES OF MEETINGS.

THE INSTITUTION OF MECHANICAL ENGINEERS.—To-night at 6 p.m., at Storeys Gate, S.W.1. General Meeting: "Irrigation Pumping Machinery (Gezira Scheme), Sudan," by Richard W. Allen. Friday, May 16, at 6 p.m. Extra general meeting. "Third Report of the Steam-Nozzles Research Committee."

THE JUNIOR INSTITUTION OF ENGINEERS.—To-night at 7.30 p.m. at 39, Victoria-street, S.W.1. Ordinary Meeting Durham Bursar's paper: "Methods of Purifying Water and Sewage," by F. W. Follett.

THE ROYAL METEOROLOGICAL SOCIETY.—Monday, May 12, at 5.15 p.m., at 49, Cromwell-road, South Kensington, S.W.7. Discussion on "Formation of Cyclones," will be opened by Professor V. Bjerknes.

THE INSTITUTION OF CIVIL ENGINEERS.—Tuesday, May 13, at 6 p.m., at Great George-street, S.W.1. Annual General Meeting of Corporate Members only.

THE INSTITUTION OF PETROLEUM TECHNOLOGISTS.—Tuesday, May 13, at 5.30 p.m., at the Royal Society of Arts, John-street, Adelphi, W.C.2. "The Geology and Oil Measures of South East Persia," by R. K. Richardson, A.R.C.Sc.

THE RADIO SOCIETY OF GREAT BRITAIN.—Wednesday, May 14, at 6 p.m., at the Institution of Electrical Engineers, Victoria Embankment, W.C.2. Informal Meeting. Discussion on "Some Suggested Lines for Experimental Research" will be opened by G. G. Blake, M.I.E.E.

THE INSTITUTION OF RAILWAY SIGNAL ENGINEERS.—Wednesday, May 14, at 6.30 p.m., at the Institution of Electrical Engineers, Victoria Embankment, W.C.2. Open discussion on "Mechanical and Electrical Detection."

THE ROYAL SOCIETY OF ARTS.—Wednesday, May 14, at 8 p.m., at John-street, Adelphi, W.C. 2. "Furs and the Fur Trade," by Mr. F. C. Ingrams.

THE INSTITUTION OF SANITARY ENGINEERS.—Wednesday, May 14, at 7.30 p.m., at Caxton Hall, Westminster, S.W.1. "Some Physico-Chemical Factors in Water and Sewage Purification," by Eric K. Rideal, D.Sc., M.A., F.I.C.

THE INSTITUTION OF MINING AND METALLURGY.—Thursday, May 15, at 5.30 p.m., at the Geological Society, Burlington House, Piccadilly, W. 1. "Carbonaceous Matter at Porcupine": (1) "Its Geological Occurrence," by J. Mackintosh Bell. (2) "Its Metallurgy," by André Dorfman; "The Constitution of Copper Mattes," by F. H. Edwards; "A Microscopic Examination of the Insizwa Sulphide Deposits," by T. C. Phemister, B.Sc.

THE ROYAL INSTITUTION OF GREAT BRITAIN.—Friday, May 16, at 9 p.m. The Evening Discourse will be delivered by the Very Rev. William Foxley Norris on "The Stained Glass of York Minster." Afternoon lecture. Thursday, May 15, at 5.15 p.m.: Dr. E. V. Appleton on "Atmospheric Interference in Wireless Telegraphy" (Lecture I).

THE INSTITUTION OF CIVIL ENGINEERS *v.* DEY AND ROY.—The Institution of Civil Engineers have called our attention to a case decided in the Chancery Division, before Mr. Justice Tomlin, on the 2nd inst., against two defendants, Birendra Nath Dey and Promod Nath Roy, who used the affix A.M.Inst.C.E., a use that was not justified. The defendants declared that they were willing to treat the hearing of the motion as the trial of the action, to submit to a perpetual injunction in terms of the notice of motion, and to pay the costs. For the defendants, Mr. E. C. Morey stated that the affix had been inserted in the headings of a few letters by inadvertence.

CLOSER WORKING IN THE RUBBER INDUSTRY.—Closer co-operation in the rubber industry, which Mr. James Fairbairn, Chairman of the Amalgamated Rubber Estates, advocated in his paper on "The Rubber Industry—a Plea for Closer Working" last Monday at the Institution of the Rubber Industry, was not discussed there for the first time. The Institution was, indeed, founded three years ago, "to promote a better understanding and a closer relationship among all sides of the rubber industry." Mr. Fairbairn dealt particularly with the planting side, recommending amalgamation and geographical consolidation of the groups and companies, which, he thought, should be reduced from about a hundred to ten groups, none of less than 10,000 acres. Of the total area cultivated with rubber in the East, 70 per cent. was British and 25 per cent Dutch. It was regrettable that the Dutch planters, or the financiers in the Netherlands, had not adopted the Stevenson scheme, which restricts the rubber plantation output when a certain minimum price of raw rubber cannot be maintained. Prices had gone down in spite of that restriction—40 per cent. of the rubber was now wasted as one member put it—and the combination of American buyers made central selling by the British planters and combination, on the lines of recent bank amalgamations and of co-operation in the South African goldfields, all the more advisable. It was striking to hear Mr. Fairbairn at the conclusion of his discourse call for some new extended use for rubber, within about a dozen years of the great rubber boom of 1910. No suggestions as to new uses were made during the discussion, which, like the paper, kept on general grounds. Anything that might endanger our friendly relations with America was deprecated by all members who spoke.

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MR. N. G. GEDYE, M.INST.C.E., CONSULTING ENGINEER; MESSRS. SIR JOHN JACKSON, LIMITED, CONTRACTORS.

(*For Description, see Page* 602.)

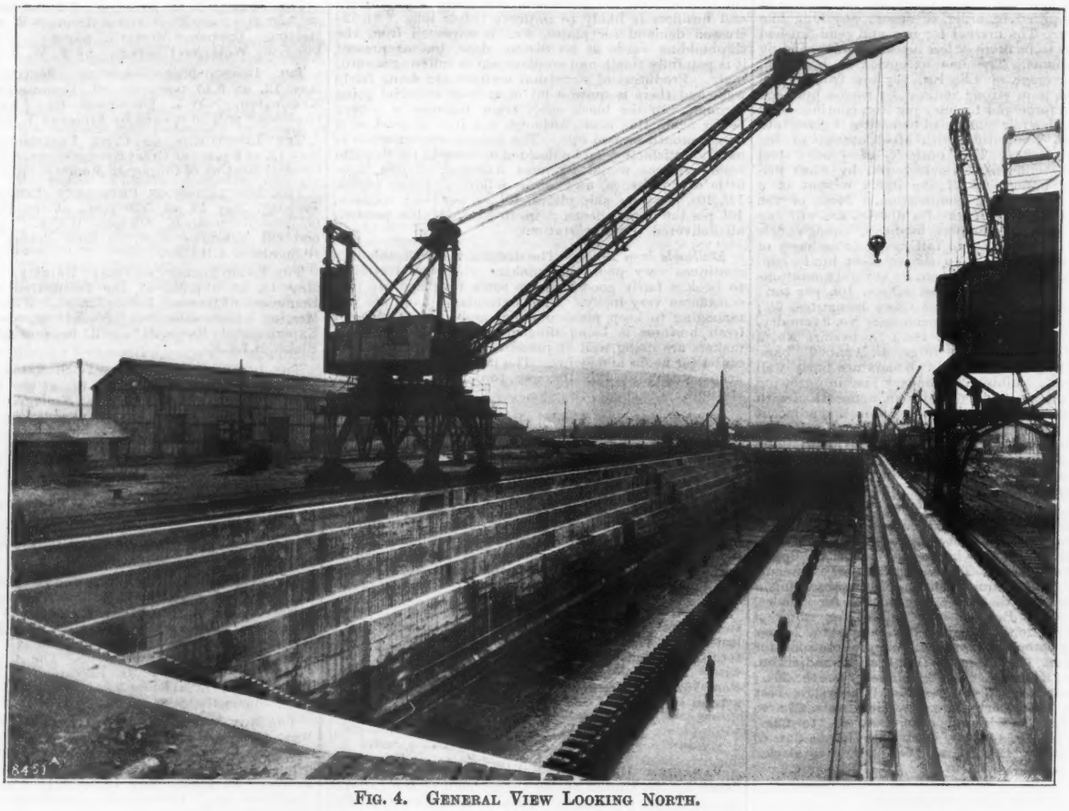

FIG. 4. GENERAL VIEW LOOKING NORTH.

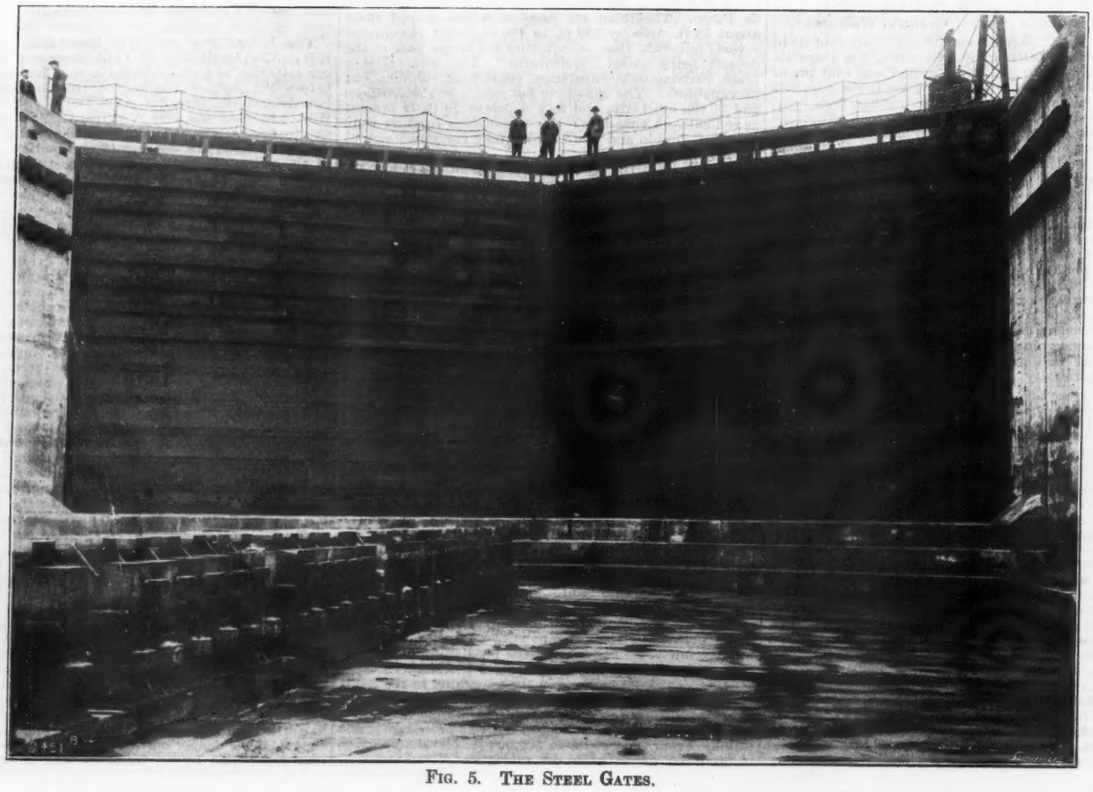

FIG. 5. THE STEEL GATES.

ENGINEERING.

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ENGINEERING.

FRIDAY, MAY 9, 1924.

ECONOMY IN STEEL-MAKING.

THE history of the development of most industries includes a period of what to later times appears as one of reckless waste and extravagance. That the metal trades were no exception to this rule was made very evident in the able and interesting presidential address delivered yesterday to the Iron and Steel Institute by Sir William Ellis, G.B.E. Vast changes have been made in the conduct of British steel works since Sir William first entered them some forty years ago. Then, waste was everywhere prevalent; both fuel and labour were relatively cheap and neither was utilised to the best advantage. Waste there unquestionably was, but at a certain stage in the development of new manufactures it is more important to social organisation to get things done than to get them done economically. In fact it is often only by experience in actual production that the possibility of important economies becomes evident. The substitution of the hot blast for cold blast in the production of pig iron was a very natural development from conditions already existing, but the problem of producing pig iron at all in coke-fired furnaces was of quite sufficient difficulty in itself to free from blame those responsible for the failure to utilise the millions of cubic feet of gas which for so many years flamed from the tops of our furnaces.

This stage, of course, had long been passed through before Sir William entered on his career as a steel maker, but the picture he drew of the conditions in British steel works forty years ago shows a state of affairs not easy to justify. Boiler pressures seldom exceeded 50 lb., and small steam engines were spread here and there over large works and fed by such long lines of badly insulated steam piping that it became almost a question as to whether the engines at the further end should be classed as steam or hydraulic motors. One case is on record in which the steam main was carried through an underground drain which not infrequently ran full of water. This arrangement no doubt commended itself to its designer as a neat way of disposing of an unsightly pipe, but the mixture which finally reached the engine must at times have contained nearly as much water as steam. Of course modern facilities for distributing power did not then exist. The electric motor was in its infancy, and exhaust steam turbines running on waste steam was not devised till many years later. Still it was known that long uncovered pipe lines were bad practice and that higher boiler pressures would save fuel.

Handling appliances were also very crude, and it is probable that there is no field in which more economies are to be effected, not only in steel works but in engineering shops. Some very striking illustrations of this were made manifest in munitions manufacture during the war. Firms, similarly equipped, engaged on the same class of work were found to differ enormously in output. In one case investigation showed that the actual cutting times in two shops were practically identical, and that the very large difference in output lay wholly in the relative efficiency of the methods adopted for handling material. Forty years ago, as Sir William points out, the modern high-speed travelling crane was unknown, and the lifting and handling equipment in most iron works was of a somewhat primitive type. In America labour was dear, and steel works there could not afford to be as prodigal of it as was customary here in the 'eighties of last century. The one point which struck visitors from this country to American steel works was the deserted appearance of the latter, as judged by British standards. Wherever practicable, muscle was displaced by power, and a far higher output per head was attained than was customary here.

In this connection, we may incidentally observe that dear labour is not always a disadvantage to a country, provided that the other conditions are such as not to prevent the establishment of a new industry. Granted these conditions, the ultimate outcome of dear labour may be to cheapen products, as the necessity for economising in a costly item induces the expenditure of much cash and much thought in improving manufacturing methods. A striking instance of this was provided a few years back in the boot trade, our own producers being undersold in their own markets by American competitors, who had been encouraged by their tariff to sink very large sums in the devising of machinery to replace hand labour. The condition of affairs which then arose was only remedied by the far from palatable expedient of our own manufacturers becoming tributaries to an American trust. Our steel works have found salvation without any equivalent sacrifice of our national pride as competent mechanics. In a Home Office report published last year, it was stated that one North Country works was turning out 1,500 tons of rails per 24 hours with a crew of four men, the rolls being fed from a 160-ton furnace.

This result is gratifying, and it is, of course, important for us to maintain our bulk trade in standard commodities. In view of the special conditions in these islands, however, it would seem even more important to develop business in goods of the highest grade. In purchasing these, customers pay largely for imponderables and not merely for muscle and materials. The importance of this distinction is far from generally recognised, and writers on economics often speak as if it were a matter of indifference to our community whether we paid for our imports by the export of china or of china clay. It is not long since our steel makers were largely tributary to Germany for important components of their special steels. This condition arose from no lack of technical ability here, but from the want of an assured market, not liable to be undercut by a temporary sale of goods below cost, undertaken with the object of closing down the native establishments.

In this connection mention should be made of the very great service the Admiralty has rendered to the iron and steel industries of this country. At

one time it must be admitted that foreign steel castings were considerably better than our own, which, save when of the simplest type, were very liable to be defective. The Admiralty would not, however, admit into British ships essential elements of other than native manufacture, and with this assured market our own makers had the opportunity of learning how to produce satisfactorily even very complicated steel castings.

We may also refer here to Sir William's suggestion that engineers requiring very large forgings such as are now needed for steam-turbine rotors, should consult makers and metallurgists before fixing designs. As matters stand, this is no doubt highly desirable, but metallurgists should not abandon the hope of gaining such a control over materials and processes that they can say to engineers of all countries: "Just tell us what you want and no matter how large or how small, how simple or how complicated, we will undertake to meet your most exacting requirements."

There is, no doubt, a long path to be traversed before such a desideratum has any prospect of attainment, but the nearer our steel makers can approach to it, the larger will be the proportion they secure of the "cream" of the trade. Such an end would be utterly inaccessible to the practical men who ruled our steel works forty years ago, but much may be hoped from the advance of metallurgical science. When important theoretical developments are announced, makers of stock merchandise often inquire, what is the good of it? Will the new knowledge make it possible for us to improve our wares in quality or to reduce our manufacturing costs? In very many cases the answer must be in the negative, as prolonged practical experience has left little or no room for improvement in articles which have perhaps been made for a generation or more. The maker of this class of goods knows very definitely what precautions are necessary to attain the results he requires, though he may have a very imperfect idea as to the *rationale* of his procedure. New theoretical developments, therefore, may be of as little direct value to him as Carnot's theorem is to a locomotive builder. Thermodynamic theory has, however, more than justified itself, as new methods of developing power were devised, and the same has been the case with metallurgical studies. No doubt structural steel of to-day is not materially different from what it was a quarter of a century ago, and its manufacture has benefitted little, if at all, by the enormous advances which have been made in metallurgical theory, but whole groups of new materials have been introduced largely as the result of laboratory research.

New requirements are, in fact, continually arising, and it is here that science commonly justifies itself. The wonderful results obtained by the heat treatment of alloy steels is a case in point. No doubt there is a vast gulf to be bridged between a laboratory experiment made on a limited scale with pure materials and the attainment of corresponding results in large masses, produced from such raw materials as it is commercially practicable to use. In this direction, however, theoretical knowledge has proved of the greatest advantage, and must in the aggregate have saved many hundreds of thousands of pounds sterling by enabling reasoned research to replace blind experiment.

DISTORTION IN RADIO-TELEPHONY.

ONE of the useful effects of the comparatively recent introduction and development in this country of the broadcasting of speech and music by radio-telephony, has been to direct a very considerable amount of attention to the design and construction of telephone apparatus capable of reproducing the sounds in their original form as closely as possible. The problem has, of course, been studied for many years in the development of land line and cable telephony, but the standard to be attained in this class of communication in order to secure intelligible speech at the receiving end is so much lower than that required for the transmission and reception of music which will satisfy a critical ear, that the difficulties involved are greatly reduced. In ordinary telephonic communication, it appears that only about half the syllables are correctly heard in intelligible speech, the remainder being understood from the context, and this fact is sufficiently indicated by the difficulty commonly experienced in transmitting isolated letters, figures and unfamiliar names. Even at the present stage of the development of radio-telephony, speech and music of excellent quality can be received in head telephones and even with some forms of loud speakers in use the results obtained are quite passable. This is really a very remarkable fact when the many possibilities of distortion existing between the source of sound in the studio of the broadcasting station and the ears of the subscriber are taken into consideration.

Some of the possible sources of distortion are examined in an interesting paper read by Mr. L. C. Pocock before the Institution of Electrical Engineers on Wednesday last and entitled "Faithful Reproduction in Radio-Telephony." In this paper the author first defines the terms suitable for use in the scientific study of the subject, and then proceeds to analyse the types of distortion occurring, afterwards laying down in a mathematical form a number of general principles, the proper understanding of which will enable individual circumstances to be examined and indicate the means to be taken to secure high-quality sound reproduction. One of the simplest forms of distortion, and at the same time one of the most difficult to eliminate from some of the apparatus used, is known as frequency distortion, which arises from the amplification of various frequencies to different degrees owing to the effects of resonance. In consequence of this form of distortion, certain notes in music will be reproduced with undue prominence and the higher harmonics, which give the notes of an instrument their particular characteristics, may be lost. To reduce the effect, the author shows that lightness of the moving parts of the mechanism of the reproducing system is essential and that the damping must be at least critical.

Another form of distortion, known as amplitude distortion, occurs when the output voltage, or force, from any element of the system is not directly proportional to the input for any frequency. This kind of distortion occurs in iron-core coils owing to the non-linearity of the B/H curve of the iron, and also in valve circuits on account of the curvature of the valve characteristic. It can, however, be greatly reduced by careful attention to the design and operation of these components.

In discussing the principles involved in the modulation of the carrier wave by speech-frequency currents and their subsequent demodulation, or detection, at the receiving end, the author deals with the causes of distortion in these processes and then goes on to describe the various types of apparatus employed in practical radio-telephony with respect to their influence on distortion. The transmitting apparatus, he points out, should be such that its voltage output, at all frequencies from 20 per second to somewhere about 10,000 per second, faithfully reproduces the variations in air pressure due to the sound to be transmitted; this, of course, implies the absence of both frequency and amplitude distortion. Dealing first with the transmitting microphone, the author mentions that the ordinary carbon-granule microphone depends for its efficiency upon resonance effects which permit a certain amount of frequency distortion. Amplitude distortion is also present unless the resistance variation is very small, together with a symmetrical distortion due to the non-linear variation of carbon resistance with pressure; this, however, can be compensated for by the "push-pull" arrangement of which an example was illustrated and described on page 560 *ante*. Excellent transmitters can, however, be made by securing high natural frequencies with high damping, so that there is no great difficulty in avoiding frequency distortion, but the elimination of resonance effects greatly reduces the transmitting efficiency, and this must be compensated for by employing a high degree of amplification. Of the various types of high-quality transmitters in use, the condenser transmitter, which operates by capacity variations corresponding to the variations in air pressure produced by the sound waves, gives quite negligible amplitude distortion, and an almost flat frequency characteristic can also be obtained. The same remarks apply to the push-pull type of carbon transmitter referred to above. In the electro-magnetic transmitter, used, we believe, by the British Broadcasting Company, a light coil is made to vibrate in a magnetic field by means of the sound waves. The output voltage, in this case, varies directly as the frequency, but the natural frequency is probably low, so that the variation of output with frequency partly compensates for the falling amplitude-frequency characteristic of the vibration; the frequency distortion can be corrected by suitable inductance.

The very weak current fluctuations produced by high-quality transmitters must be greatly amplified before they can be employed to modulate the carrier wave, and this is done by means of one or more valve amplifiers. To avoid distortion in the latter, when used with either transmitting or receiving apparatus, it is necessary to consider the characteristics of the valves, the method of coupling and the combination of valves and couplings. In the case of the valve, the grid voltage/plate current characteristic under working conditions must be linear over a certain range and the instantaneous voltage applied to the grid circuit must not exceed the limits corresponding to linearity in the plate current. These conditions will be practically fulfilled, provided the valve has sufficient capacity for its work, if the values of the grid voltage and plate voltage are correctly chosen. For coupling valves, the impedance-condenser and transformer methods are employed, the impedance being either a high resistance or a large inductance. Resistance coupling gives good quality with freedom from frequency distortion, but requires a high-voltage battery; good results can also be obtained with inductance-capacity coupling if suitable precautions, referred to in the paper, are taken in the design of the inductance. Transformer coupling, however, has the highest overall efficiency, but, at the same time, presents the greatest difficulty in avoiding distortion.

The fact that, by means of transformers, the voltage can be stepped up between the valves, reduces the number of the latter required for a given degree of amplification, but very careful design is necessary to avoid serious resonance effects due to the capacity of the secondary winding. The iron circuit of audio-frequency transformers must also be proportioned on generous lines in order to reduce frequency and amplitude distortions, but in spite of the difficulties involved, it is possible to employ transformer coupling successfully in high-quality amplifiers. The consideration of the combination of valve and coupling in audio-frequency amplifiers is necessary, because the thermionic valve is not perfectly unilateral in its behaviour, but we do not propose to follow the author's treatment of this part of the subject.

With regard to the use of reaction in receiving circuits, the author states that a moderate degree can be properly employed to increase the sharpness of tuning when receiving faint telephony. He points out, however, that if reaction is carried too far, the curve of aerial current against frequency, for a constant applied voltage, will become sharply peaked and the band of frequencies corresponding to the telephonic signals will no longer lie on a sensibly flat part of the resonance curve; frequency distortion will thus be introduced. For this reason, the author regards the Armstrong super-regenerative circuit as unsuitable for the reception of high-class telephony, and he also expresses the opinion that dual-amplification, or reflex, circuits are also open to objection from the point of view of high-quality reproduction.

The final transformation of the electrical current fluctuations into sound waves takes place in the telephone head pieces or loud-speaking telephone connected with the receiving apparatus. With the former a certain amount of mechanical resonance appears to be necessary to secure reasonable efficiency and receivers are, therefore, less than critically damped. A satisfactory compromise between efficiency and faithfulness can, however be reached in practice and the results obtainable leave little cause for complaint. Loud-speaking telephones, on the other hand, are less satisfactory and some of their defects were dealt with in a joint

discussion by members of the Institution of Electrical Engineers and the Physical Society of London, reported on page 718 of our last volume.

Mr. Pocock, in referring to this subject, remarks that loud-speaking receivers can be designed to give a required output without amplitude distortion, provided that they are used with amplifiers of adequate capacity. Frequency distortion is, however, the most serious problem in high-quality sound reproduction by these instruments, but even in this respect, a near approach to perfection is attainable though not, at present, at a commercial cost. Electromagnetic receivers, he points out, can only be made of sufficiently high efficiency to enable them to be used with valves of moderate power by employing mechanical resonance, and it is by the sparing use of resonance, which results in a sacrifice of volume efficiency, that high quality has at present to be secured.

FRENCH NAVAL REORGANISATION.

THE French Parliament has recently been presented with a bill for reorganising the French dockyards. It has been examined and made the subject of fairly long reports by naval committees in the Senate and Chamber of Deputies; and the thoroughness of these documents shows that, if the French Parliament is slow to vote naval credits, it is at least willing to make the most searching enquiries into its naval affairs.

At present France has six naval bases: Brest, Cherbourg, Rochefort, Lorient, Toulon and Bizerta, which are in part supplied by three naval factories for guns, munitions, anchors, cables and armour: Indret, on the lower Loire; Guérigny, in the centre of France, near Nevers; and Ruelle, in south-western France, near Angoulême. These bases and supply establishments do not owe their existence to any fixed plan. Practically all of them were founded by the great French naval administrators of the early seventeenth century. Toulon, for instance, was made a naval arsenal in 1604 by Henri IV; Indret was, it is true, only made a regular naval depot in 1777, but it had been hall-marked as a supply place for naval material as early as 1642. In some respects the French dockyards have adapted themselves to the requirements of a modern fleet, in others they have failed to do so. The projected law on naval bases is therefore intended to set the naval arsenals of the country in order, and so remedy the existing confusion.

It is proposed that Brest shall be a main base for the Atlantic and Channel, and Toulon for the Mediterranean; and that Cherbourg shall be maintained as a *point d'appui* for the northern squadrons and Bizerta for the southern ones. The base at Rochefort is to be wholly suppressed; Lorient is to be kept simply as a place for building new ships: whilst the factories at Guérigny are to be transferred to Indret. These proposals are accompanied by sweeping recommendations with regard to the plant and workshops of the existing bases.

Brest cannot build vessels more than 670 ft. long, but the arsenal is well fitted in other respects. Monsieur de Chappedelaine's committee recommended that new construction quays, capable of building the larger vessels allowed for under the Washington agreement should be taken in hand. To do so, three additional kilometres of wharfage and two basins, each of about 400 yd. long, would have been necessary. The work would have taken ten years and would have cost 235 million francs. The Senatorial report says that such a project must be "resolutely set aside"; the country cannot afford it; and "it would be absurd to undertake work of such importance before it is certain that France will ever have to build capital ships 800 ft. long." The whole question of battleship construction seems to be under consideration by the Conseil Superieur de la Marine. The Senatorial report, none the less, recommends that the torpedo range at Brest shall be transferred to Ile Longue and entirely renewed, and that the gun foundries at the port shall be brought up to date. Both the plant and the installations are in a very bad condition.

As has been said, Cherbourg is to be made a *point d'appui*. The meaning of this phrase is explicitly added to the proposal. "A *point d'appui* is a port where vessels of every class can find such protection against enemy ships as may be necessary for reprovisioning or carrying out such temporary repairs as will enable them to reach their main base." Cherbourg is at present over-equipped. The law therefore proposes to lend the big 790-ft. basin to the local chamber of commerce, but to keep the naval munitions factory in an up-to-date condition as an arsenal for the coastal defences of the northern maritime frontier. At present four submarines of the new building programme are being constructed at Cherbourg. The Senatorial report strongly urges that, as soon as the work is finished, all the building plant shall be sold or let to private firms, "in order to keep to the conception of a *point d'appui* as defined by the Ministry of the Marine."

Toulon, the main base for the French fleet in the Mediterranean, seems to be well supplied with plant and installations, but the report draws attention to a constant weakness in the labour supply. Six thousand workmen are needed for the construction and repair of ships. There are at present about 5,350, and the number is falling. None the less, Toulon arsenal seems to be one of the best fitted munition factories in the country. In addition to supplying the Mediterranean fleet and the anti-submarine flotillas with all they required during the war, the arsenal turned out 70,000 field gun fuses and 20,000 field gun cartridge cases per diem, in addition to a large quantity of heavy artillery. Its daily output of melinite was increased from 2 tons to 80 tons per day, and its manufacture of fulminate of mercury from 150 tons per annum to 550 lb. per diem.

Bizerta, the *point d'appui* of the Mediterranean fleet, is stated in the report to be "the only one of our dockyards which was built on a singly conceived plan." No special outlay or reconstruction is necessary to adapt it to the uses for which it is intended under the new law. A new foundry costing a million and a-half francs is the only thing recommended.

Neither the Senate nor the Chamber of Deputies seems inclined to question the wisdom of suppressing the Rochefort dockyard. Created by Colbert in 1665, it is simply a survival of an earlier age. It lies well up the Charente river; a vessel more than 330 ft. long can hardly reach it, and its plant and installations are hopelessly out of date. The question of Lorient is not so easy. On the one hand, it possesses the largest government dock in the country, and its basin and dockyard plant are up-to-date and in good order. On the other hand, Lorient has no fleet anchorage, and for that reason can never be a naval base. The Senatorial committee urges most strongly that it is a bad principle to "accumulate naval material and personnel at a place of no naval importance. Reason (*logique implacable*) demands that the dockyard at Lorient should be suppressed, as its historical role is over. The idea of making Lorient a model state factory is a ruinous and deceptive fantasy. . . ." The recommendation is, therefore, that a sum of about seven million francs shall be spent on the place, but that no large ships shall ever be laid down there. "Parliament cannot agree to expenditure upon a condemned harbour, undertaken with a view to presenting the country with an accomplished fact, which would be used to justify the upkeep of the place in future." It is on this point that the report is rather difficult to understand. A project which would have replaced the Lorient yard by another, more conveniently and centrally placed, is turned down, and yet at the same time it is strongly recommended that Lorient dockyard, the only place capable of building big battleships, shall be gradually suppressed. The refusal to extend the Brest dockyard is the more remarkable in that the report particularly insists upon the principle of concentration. "There is no thought of drawing attention to the decline of our fleet, and then of perpetuating it, by reducing the number of our naval establishments. We are here concerned with restoring our navy, by concentrating our means of action upon points of our territory, which are as limited as can be."

There is another reason why the report does not seem very consistent. The proposal to suppress Lorient by degrees, and to leave Brest as it is, implies that the committee have been much influenced by the scepticism about capital ship construction, which has recently expressed itself so strongly in expert French circles. But if, as many think, and apparently the reporter amongst them, the French navy can best be reconstructed by building a very large fleet of submarines and flotillas, with a backing of powerful cruisers and a huge air force, then, is it so certain that Lorient and Rochefort are places of "no naval importance?" A dockyard well away from the coast, on the banks of a winding waterway, might well be a submarine base of the first order.

The French parliamentary commissioners have added an analysis of the naval budget to their report on the dockyards. In it they have endeavoured to divide the money spent upon the French navy into productive charges, that is, all sums which directly support the fleet's military efficiency, and overhead charges of a purely administrative kind. They do not state how they have arrived at their figures, but some of the results are extremely interesting. From 15 to 20 per cent. of the total naval expenditure is spent upon making good the ordinary wear and tear of ships, whilst industrial work in the dockyards costs about 35, and the arming of the fleet from 30 to 40 per cent. of the naval budget. The British naval estimates have never been analysed on the same lines, so that it is impossible to say how our figures would compare with theirs. The results of their survey have, none the less, alarmed the French parliamentary commissioners. With regard to the dockyard expenditure, Monsieur Lémery remarks: "Nothing could show more eloquently what our budget is suffering from. If one reflects that in 1922 (when no ships were being built) our dockyards cost 342 millions of francs, one must admit that dockyard reform is an urgent necessity, and that if it is not undertaken our navy will be in a fair way towards ruin."

The percentage of naval work carried out by private firms is at present about 25; and it is to this point that the commissioners attach one of their strongest recommendations: "It is important that a serious effort should be made to renew the fleet by decreasing departmental expenses, and by increasing the amount of work carried out in private industries. Expenditure of this kind makes the whole budget more productive in that it does not increase departmental charges, and it may be contracted, or even suppressed, as the general naval policy of the country demands."

THE THERMAL PROPERTIES OF METHYL CHLORIDE.

AMONG the substances proposed for use in machines for mechanical refrigeration is methyl chloride, and perhaps more often it is suggested as an addition in small proportion to ethyl chloride for the same purpose, or is found as an impurity in commercial ethyl chloride. The liquids and their vapours differ little from each other in most respects, except that methyl chloride boils at about − 24 deg. C. as against + 12·5 deg. for ethyl chloride, with corresponding differences in the saturation pressures and specific volumes of saturated vapour. The presence of methyl chloride in ethyl chloride, though it will not much affect the total heat of either the liquid or the saturated vapour, will thus raise the vapour pressure, and a knowledge of the actual thermal properties of methyl chloride is therefore desirable for the purposes of refrigerating practice.

The Engineering Committee of the Food Investigation Board, of which committee Sir James Ewing is chairman, has already submitted ethyl chloride to experimental investigation with the object of measuring its thermal properties and constructing $\theta\ \phi$ and $I\ \phi$ diagrams for the service of refrigerating engineers. This work was done by Professor C. F. Jenkin, with the assistance of Mr. D. N. Shorthose (see ENGINEERING, vol. cxvi, page 761), and the Committee has now published a similar report on methyl chloride, conducted by Mr. Shorthose under Professor Jenkin's supervision and in his laboratory.*

* The Thermal Properties of Methyl Chloride. H.M. Stationery Office, 1s. net.

From the data so obtained, supplemented in one or two instances by figures already available, $\theta\ \phi$ and $I\ \phi$ diagrams have been prepared. Having regard, presumably, to the closeness to be expected between the results of these determinations and those made with ethyl chloride the methods adopted were such as did not require the costly apparatus and relatively large quantities of the substance that were used in the determinations of ethyl chloride. The results, however, obtained by applying some of these methods to ethyl chloride agreed closely with those of the earlier investigation, and the occasional uncertainty arising from the omission of some determinations amounts probably to less than 1 per cent., so that at least for the present no great purpose would be served by extending the experiments so as to obviate this small uncertainty.

The most notable variation from the methods of the ethyl chloride determination was in the measurement of the specific heat of the liquid, which had been made in the earlier work with a continuous flow calorimeter involving a large quantity of substance and some complexity of operation ζ (ENGINEERING, v. cxvi, p. 761). In the present determinations the specific heat was deduced from the known specific heats of alcohol and carbon bisulphide by comparing the cooling curves of the liquids. For this purpose the liquid under examination was introduced into a glass bulb of about 25 c.c. capacity with a narrow stem, which projected through a tube closed top and bottom, with a little phosphorous pentoxide in the bottom of the tube to keep the air dry. The liquid only reached part of the way up the stem, and its height, read with a cathetometer from a mark etched on the stem, was a measure of the mean temperature of the liquid. The thermometer so formed was calibrated with a standard thermometer for each liquid. For a test the bulb in its air jacket was cooled to —45 deg. C. and put into a bath, kept steady near 0 deg. C. by melting ice and an electrically driven circulating pump, and the rate at which the temperature of the liquid in the bulb rose was read every few degrees and a curve plotted for the range —30 deg. C. to 0 deg. C. The experiment was repeated with the bath kept at 32 deg. C. by an electrical heater, and a curve plotted for the heating of the liquid from 0 deg. C. to 30 deg. C. With this arrangement the rise of temperature was not too rapid; and as volumes of liquid equal at 0 deg. C. were used, the expansions in the several experiments occurred over about the same part of the tube, and the readings of the stem of the bulb were comparable. The heat capacity of the bulb (which varies with the temperature) having been determined by calculation from the results with alcohol and carbon bisulphide—chosen because their heat capacities per unit volume are very different—the specific heat of the methyl chloride was calculated by comparing its heating or cooling curve with that of either of the other liquids. The result was the same with whichever liquid the comparison was made, and the value obtained by this method for the specific heat of ethyl chloride agreed closely with that obtained by the continuous flow method.

NOTES.

PROGRESS IN PHOTOGRAPHY.

SOME particulars of recent remarkable advances in photography were given in a lecture to the Society of Arts, delivered last Wednesday evening, by Mr. T. T. Baker, director of research at the laboratories of the Imperial Dry Plate Company. It is common knowledge that plate speeds have of late been very notably increased. To-day, Mr. Baker states the range of speed is 1,000 to 1, whilst there has been an even more striking development of the range of sensitiveness. The plates now manufactured respond to light ranging in wave length from one Angström unit up to a wave length of 50,000 Angström units. With plates sensitive to ultra-violet light it is now possible, Mr. Baker stated, to photograph structures far too minute to be revealed by visible light. Moreover, an aeroplane surveyor can, he said, take satisfactory photographs of landscapes so shrouded in mist as to be almost invisible to the naked eye. Studies of the formation of the sensitive emulsion showed, he said, that the precipitate of silver bromide first found was so extremely minute as to be invisible even under a magnification of 10,000 diameters. Once formed these crystals rapidly increased in size and could then be seen to consist chiefly of flat triangles and hexagons. The sensitiveness of a plate lay mainly in the size of these crystals, and this could now, he said, be controlled with remarkable accuracy. Observations of the process of development had shown that under certain conditions the silver bromide crystals "burst," throwing off shoots which joined up with adjacent crystals, thus forming large grains, which were fatal to fine definition. Recent development in photo-micrography due to Mr. N. P. Chopra, enabled magnifications of 25,000 diameters to be attained. The speaker had himself designed a new lens transparent to ultra-violet light which made it possible to reduce exposures to one fifth of what had hitherto been necessary, so that with these lenses, a plate rated at 600 H. & D. would have an effective speed equivalent to 3,000 H. & D.

THE FORTIETH ANNIVERSARY OF THE JUNIOR INSTITUTION OF ENGINEERS.

Many of our readers may remember that the energetic and flourishing engineering society now known as the Junior Institution of Engineers was brought into being just 40 years ago by a number of the apprentices of the Lambeth Works of Messrs. Maudslay, Sons and Field, which, with a number of other Thames-side engineering works, have now ceased to exist. Sir Archibald Denny, in proposing the toast of "The Institution" at a dinner held at the Café Monico on Tuesday last to celebrate the fortieth anniversary of the Institution, reminded the younger members of the above-mentioned fact, and stated that at the end of 1884 the roll of membership included only about 20 names. Twelve years later, at the time when Sir Archibald was himself President, the membership had increased to 373, and at the present time, he said, there were some 2,000 corporate members, in addition to a number of cadet members, in all parts of the country. He referred to the valuable help which young engineers derived from the papers and discussions at the formal and informal meetings, and advised them particularly to take full advantage of the facilities offered by the Institution for visiting all classes of engineering works. Mr. C. O. Mourant, in responding to this toast, expressed the view that the friendships formed among the Institution's members, which greatly influenced their careers, were among the principal reasons for its success. The toast of "Marine Engineers," proposed in a happy speech by Mr. W. J. Tennant, was responded to by Sir J. Fortescue Flannery, Bart., the President of the Institution, who occupied the chair at the dinner. He called attention to the need for specialisation in engineering work, and referred to the rapid progress in marine engineering and other branches of the profession in recent years, concluding his remarks with the assertion that, while the past achievements in engineering could be justly regarded with pride and satisfaction, those of the future would be even greater. Many past and present officers of the Institution were present, including Capt. H. Riall Sankey, who was president last year. Representatives from many of the local sections, which play an important part in the Institution's work, were also present. There are now six local sections in different parts of the country, as well as one in Melbourne and another in Assam.

CHEMICAL RESEARCH IN INDIA.

When the decline of certain Indian chemical and textile industries was touched upon at the London International Chemical Congress of 1909, Sir Edward Thorpe remarked that British chemistry had not helped Indian industry as it might have done. The Indian Industrial Commission, appointed in 1916 to inquire into the possibilities of further industrial development, reported in 1918 that the economic development of India since her coming in contact with Western traders had in many ways been disadvantageous to the interests of the country, and it urged the need of a powerful stimulus to start that development. A special committee was then elected to formulate proposals for the organisation of a Chemical Service for India, as one of the foundations of all industrial developments. The chairman of this Committee, Dr. Jocelyn F. Thorpe, F.R.S., professor of organic chemistry at the Imperial College of Science and Technology, S.W., toured throughout India in the winter 1919–20. Discoursing on "Chemical Research in India" at the Royal Society of Arts last Friday, he saw no reason why the recruitment to the suggested service should not become wholly Indian in the near future, though the recruits would need at least one year's training in Europe prior to enlistment. The so-called technological institutes could not help in that training, because they were mainly trade schools serving local interests, and Professor Thorpe rightly insisted that the introduction of commercial research into research schools only "fostered cupidity, secretiveness, and every other anti-scientific vice." The Indian Institute at Bangalore, he said, was again reverting to that higher level for which Mr. J. N. Tata had founded it. The Indian Commission had recommended a central research Institute under the Government of India at Dehra Dun, with subdivisions into agricultural, organic, and mineral chemistry. But Dr. Thorpe found that the provinces would have nothing to do with that scheme, and he agreed that provincial research institutes, limited in their activities to immediate local industrial requirements, would be preferable. In England consulting chemists would object, and the manufacturer would find an excuse for not starting a research laboratory of his own. But India had other objections, one of them, raised by Sir Prafulla Ray, being that the new chemical service would become a dumping ground for the incompetent. The chemist, Professor Thorpe recommended, should partly be trained in works, and there should be frequent interchange between the junior personnel of the staffs. Outlining the way in which the recommendations of his committee could be carried out with special regard to the resources of India, Dr. Thorpe mentioned also that a course of six months would suffice for the chemist to acquire a working knowledge of engineering. He remains in favour of a central Institute in addition to the provincial research colleges.

WORKSHOP LABORATORY AT THE BRITISH EMPIRE EXHIBITION.

WHILE deferring further description of the exhibits of purely scientific instruments displayed at the British Empire Exhibition it is now proposed to deal with the evidence of the great developments that have taken place in the application of scientific knowledge to industry. In a broad sense, and even although some early development was largely due to the use of the crude and slow methods of trial and error, it must be accepted as axiomatic that every exhibit in the Palaces of Engineering and Industry provides evidence of this application of science to modern activities. New materials have been introduced into engineering construction, either to save weight or to reduce the costs of manufacture or running, and these changes have been made possible through the more complete understanding of the structure, composition and properties of materials obtained in continued research. There is no finality to this work, and even greater progress may be anticipated in metallurgical developments in the future than we have ever known in the past. Every industry has its metallurgical problems, and it is undoubtedly true to-day that engineers of all types are confronted with difficult problems, the solution of which would be simple if exact and all-extending knowledge of metals was available. Resources have grown, and the knowledge acquired through experimental investigation of the properties of materials gives rise to hopes of great improvements to come. Not only in the improvement of materials are the results of the application of science to be seen. In the design of all types of plant the deductions from experimental work have proved of great value. The fundamental principles of electro-magnetism are the basis of the design of all electrical plant. Without exact knowledge of these actions, the design of a generator, motor or any of the thousand and one electric appliances which

depend for their operation on electro-magnetism, with any approach to the desired characteristics, would be impossible. The same conditions apply in almost every type of plant that could be referred to, but the evidence though present may not be so strikingly apparent. Much remains to be done, and if Britain is to maintain her position of industrial supremacy no slackening off can be tolerated.

There is a great indication of what is being done by large manufacturers in this phase of development by the display of plant at the British Empire Exhibition, and many outside the ranks of those intimately associated with manufacture will get a better understanding of the outlook from the fact of the erection of a research laboratory at the Exhibition as an important item in the exhibit of Messrs. Vickers, Limited. This display is evidence of the careful work which must be done if absolute reliability is to be ensured in the products of a large industrial concern. One side of the experimental work shown in progress in this laboratory, and an example of great significance in the maintenance of an exceptional reputation for sound manufactures, is found in the testing of raw materials and the metal produced from them. The position is this. In every business transaction the buyer must have definite knowledge of the characteristic commodity he is purchasing. Should the article in question be a piece of engineering plant, he might satisfy himself by the drafting of an exacting specification and then leave it to the constructors to meet the conditions. When he does so, he may not be fully conversant with all the work that has been done to ensure that new materials are available of such a physical nature as better to meet the requirements. Without the knowledge of what can be done to improve the properties of metals the purchaser may for long make stipulations in his specification which, while they may cover the requirements in regard to strength, may prove costly and be excessively heavy. Modern engineering manufacturers show great thoroughness in this work, for the demands of competition make necessary the establishment of great laboratories, not only for the study of the materials already in use but for the experimental work necessary to the production of more suitable ones. The importance of this work is evident, and Messrs. Vickers, Limited, have shown their faith in it by their laboratory exhibit. Confidence is bred of knowledge, and once the reputation of a firm is established for its painstaking endeavour to overcome the peculiar irregularities that in one way or another manifest themselves within the metal of a structure, confidence in their products will follow as a natural consequence. That then is the lesson of the laboratory, but we can learn more of its significance by an examination of the apparatus installed and a consideration of the tests demonstrated.

Much experimental work was done by the firm in former days, and among the exhibits shown to illustrate this there is an example of the crystallisation of steel in the feeding head of a large steel casting discovered about 1880 by the late Colonel T. Vickers, C.B. While in the main casting the combined carbon was 0·34 per cent. its value was 0·43 per cent. in the head. A complete analysis of one of the steel crystals was found to give the composition in percentages as :—combined carbon 0·43, silicon 0·19, manganese 1·05, sulphur 0·10, and phosphorus 0·10.

Among the instruments shown in use in the laboratory, there is a Quartz Spectrograph, by Messrs. Adam Hilger, Limited, for the detection of the presence of the various constituents in alloys. When these contain large quantities of iron, nickel, tungsten, titanium and other metals, their presence is clearly indicated by the lines in the spectra obtained. The instrument is also available for the discovery and identification of traces of all the usual metals, as well as boron, silicon, phosphorus and arsenic. By its use, samples from the various metals may be examined, so as to ensure that there is no accidental mixing of steels of various compositions in the steel works. Another interesting item displayed is Dr. Müller's X-ray Spectrograph, also made by Adam Hilger, Limited, which was recently illustrated and fully described in ENGINEERING (see page 46 *ante*). Those interested in the microscopic examination of metals (and every engineer must be included in that class) have an opportunity of witnessing the preparation of specimens, while a study of them is made possible by the complete equipment in the laboratory, which includes a projection apparatus. The qualities of metals have been improved by the use of the results of such investigations, and samples are available in the research exhibit which bear this out. In one case there is collection of examples of metals, including a specimen of a high tensile brass with a yield point of 32 tons per square inch and an ultimate strength of 52 tons per square inch. This brass gives an elongation of 15 per cent. on a tested length of 2 in. The specimens were cast in sand and received no subsequent heat treatment or other manipulation after casting. Another item is a specimen of Vickers' Crown Metal. This is a high tensile alloy of copper, nickel and zinc. The yield point it has is 24 tons per square inch, and it resists tension up to an ultimate value of 40 tons per square inch, giving a 14 per cent. elongation on 2-in. specimens. This material is not only strong, but of reasonable toughness, and has proved of great value for service in contact with certain liquids on account of its non-corrosive properties.

Heat treatment properly controlled gives great possibilities of improving the qualities of steel, and in this laboratory the process is shown in operation, while various temperature control devices are installed, the use of which ensures the maintenance of the required temperature conditions. Hardness comparison of various metals is shown by the use of the ball indentation and the diamond methods. Instruments are exhibited which are designed for the rapid determination of the thermal conductivities of metals, for the testing of the permanent magnets of magnetos and instruments, and for the high-tension testing of the mica used in condenser construction. Testing of magnet and ignition coil windings is shown as well as the use of a rotating spark gap for the test of ignition apparatus at high speed.

On the fuel side, samples are shown of what is obtained as by-products in the low-temperature carbonisation of coals, lignites and other carbonaceous matter by the methods adopted by Vickers, Limited, and the V.L. Oil Processes, Limited, while the Fusion Corporation products are also shown. A strain-viewer is exhibited, which was designed for the examination of glass ware to detect the presence of strains in commercial glass articles. Such strains are caused by too rapid or localised cooling and are a fruitful cause of breakages. Messrs. Adam Hilgers, Limited, show their optical gauges for use on small repetition parts, which we described in detail in ENGINEERING of January 4, this year. The method depends on a simple application of the principle of the Wilson Projection Comparator, which is also exhibited, and is described and illustrated on page 506 of this issue. For the preparation of accurate screwing tools the Wolseley Thread Grinding Machine was introduced, and its use is demonstrated in the laboratory, in the grinding of threads after the metal has passed through the hardening process. With this machine, screw gauges are produced directly to the reference limits of the National Physical Laboratory. Many other laboratory devices are shown, and in addition, there are exhibits of high-class surveying, astronomical and other instruments made by Messrs. Cooke, Troughton and Simms, Limited, but sufficient has been said to indicate that whatever has been possible in the illustration within an Exhibition of the activities in a research laboratory of a works, is to be seen in the research section of the stand of Messrs. Vickers, Limited.

Much is heard by the general public of the research work done by industrial concerns on the Continent, but they have not yet realised to what extent similar work is done in this country. That the manufacturers and scientific workers are fully alive to the value and significance of scientific work is ably demonstrated by this inclusion of a research laboratory on the stand of a firm at an exhibition, which is the first instance, we believe, of such an action on record. In a demonstration of the combination of inventive and manufacturing abilities of the British people, which is provided by the British Empire Exhibition, the significance of the work done in the works' laboratories deserves some prominence and on that account there is more than mere justification for this extremely interesting innovation.

LITERATURE.

Theory and Practice of Mine Ventilation: A text book for Students and a book of reference for Managers. By THOMAS BRYSON, A.R.I.C., M.I.Min.E. London: Edward Arnold and Co. 1924. (Price 8*s.* 6*d.* net.)

VARIOUS legal enactments have insisted upon the provision of improved and efficient ventilation of mines, placing of necessity greater responsibility on mine officials. Insistence on the employment of properly trained persons, qualified by the test of examination, has led to the production of a varied technical literature, to which this work makes a welcome addition. It is intended, among other purposes, to provide students with the information required by examiners from candidates for appointments, but at the same time it presents an intelligent theory on which the scheme of mining ventilation can be founded, and exhibits the application of sound scientific principles. The author is well qualified for the task undertaken, not only by his own original work on details of mining ventilation, but by experience gained from actual contact with mining operations.

The problem considered generally is a branch of hydraulics. Anemometers take the place of current meters, Venturi and Pitot tubes need little alteration from their original construction to fit them for such enquiry, the theorem of Bernouilli finds ready application, and perhaps it may be said that the same baffling factors, arising from the effects of friction enter and defeat the accuracy at which the mining engineer aims. Intelligent experiment has, however, given precision to the problem, removed many difficulties, directed attention to unsuspected causes of failure, improved the theory and set a higher standard for attainment. Mr. Bryson's little book adequately explains how the problem has been simplified and the degree of success that has been achieved.

The author describes with considerable care the nature and the constituents of the atmosphere with the character of the change effected by the introduction of gases arising from the oxidation of coal, the decay of organic matter, the decomposition of explosives, and by other impurities. These are simple matters, but they lie at the foundation of the science of ventilation, and they are specially valuable if they bring home the conclusions derived by Dr. Leonard Hill and others on the causes that effect the health of the workers and the safety of mines. In popular estimation, the cause of "closeness" has long been ascribed to an excess of carbon dioxide in the air breathed. One of the coal mining Acts requires that the amount of CO_2 in the general body of the air must be less than 1·25 per cent., and it is to be feared that much money has been wasted in trying to reach this unnecessary degree of purity. It is now known that as much as 3 per cent. of carbon dioxide in the air produces no deleterious effects; indeed, the partial pressure of this gas in the alveolar air is the normal regulator of the respiratory act. But if the dioxide is accorded a less unfavourable position, the monoxide is still regarded as an insidious, deadly foe, to be combated on every occasion. The author states that any percentage above 0·15 must be regarded as distinctly dangerous, for the effect of this poison is cumulative and in no long time the blood of the miners would become saturated and death would supervene. Recent research, therefore, has not lessened the demand for ventilation; it has rather increased its urgency. Ventilation is directed as much to the maintenance of a suitable temperature as to the removal of toxic gases. The enervating effects of close and confined conditions are well recognised, and if CO_2 is regarded as comparatively harmless, heat stagnation is an enemy to be vigorously fought, since it lowers the energy and vitality of the worker.

Having explained the origin and operation of the deleterious materials in the mine and the need for their removal, the author next describes the mechanism by which this end is attained, through

the use of a ventilating system, arranged to draw air either from the top of the upcast shaft or by blowing air into the mine. In either case a rotating fan is the primary agent, and of these, many forms are in the market at the command of the engineer. Several of these are quite adequately described, and though the descriptions must of necessity resemble those found in manufacturers' catalogues, the critical remarks and comparisons of the relative merits of varied designs, relieve the text of the weariness of repetition. The selection of a suitable fan for application to a particular environment must entail great responsibility, and we should doubt if it is possible to reduce the problem to the narrow limits Mr. Bryson thinks feasible. The resistance of a mine must vary considerably as development proceeds, and, according to the method adopted, whether "pillar and stall" or "longwall." Though much has been achieved by direct experiment, it is questionable if the time has arrived for the adoption of a rule defining the unit of resistance. The author favours the use of a simple formula, as h/Q_2 (where Q is the volume of air passing through the mine per minute and h denotes the height of the water gauge in inches) as the most scientific and convenient expression of a mine's resistance. The conception of the "equivalent orifice" is another means of expressing the resistance which has been recommended. The orifice here considered is the area of a hole in a thin plate which allows the same quantity of air to pass through it as passes through the mine, with the same depression as that required to ventilate the mine. The author is at much pains to discuss the methods of estimation, and we gather that it is not without satisfaction that he is able to show that under certain conditions, the relations existing between Q and h can be conveniently substituted for those proposed.

BOOKS RECEIVED.

United States Geological Survey. Forty-Fourth Annual Report of the Director to the Secretary of the Interior for the Fiscal Year ended June 30, 1922. Bulletin No. 749. *Geology of the Tullock Creek Coal Field, Rosebud and Big Horn Counties, Montana.* By G. S. ROGERS and W. LEE. [Price 50 cents.] No. 760A. *Pedestal Rocks in the Arid Southwest.* By K. BRYAN. Washington: Government Printing Office.

Wireless Sets for Home Constructors. By E. REDPATH. London: Radio Press, Limited. [Price 2*s.* 6*d.* net.]

Electrical Measuring Instruments. Part I—*Commercial and Indicating Instruments.* By C. V. DRYSDALE, O.B.E., D.Sc., M.I.E.E., and A. C. JOLLEY, A.M.I.E.E. London: Ernest Benn. [Price 55*s.* net.]

Alignment Charts for Engineers and Students. By W. J. KEARTON, M.Eng., and GEORGE WOOD, A.M.I.Mech.E. London: Charles Griffin and Co., Limited. [Price 16*s.* net.]

500 *Wireless Questions Answered.* By E. P. RENDALL and E. REDPATH. London: Radio Press, Limited. [Price 2*s.* 6*d.* net.]

Die Eisenkonstruktion der Ingenieur-Hochbauten. By Dr. Ing. e. h. Max Foerster. Fifth edition, revised and enlarged. Leipzig: Wilhelm Engelmann. [Price 45 Gold Marks.]

The Industries of the Clyde Valley during the War. By W. R. SCOTT, M.A., D.Phil., Litt.D., LL.D., and J. Cummin, M.A. Oxford: The Clarendon Press. [Price 10*s.* 6*d.* net.]

Measurement, Compression and Transmission of Natural Gas. By LESTER CLYDE LICHTY. New York: John Wiley and Sons, Inc. London: Chapman and Hall, Limited. [Price 37*s.* 6*d.* net.]

Elastizität und Festigkeit. By C. BACH and R. BAUMANN. Ninth edition revised. Berlin: Julius Springer. [Price 5·75 dollars.]

Structural Engineering. By JOSEPH HUSBAND, M.Inst. C.E., and William Harby. Third edition, revised and enlarged. London: Longmans, Green and Co. [Price 16*s.* net.]

Emergency Water Supplies for Military, Agricultural and Colonial Purposes. By A. BEEBY THOMPSON, O.B.E., M.I.Mech.E., F.G.S. London: Crosby, Lockwood and Son. [Price 21*s.* net.]

Ministero Dei Lavori Pubblici. Memorie e Studi Idrografici con Appendice sulla Produzione di Energia nel 1922. *Parts* 1 *and* 2. Rome: Tipografia del Senato del Dott Giovainni Bardi. [Price 20 lire each.]

Gemeinfassliche Darstellung des Eisenhüttenwesens. Edited by Vereine Deutscher Eisenhuttenleute in Dusseldorf. Dusseldorf: Stahl und Eisen, M.B.H. [Price 14*s.*]

Praktisches Maschinenzeichen mit Einführung in die Maschinenlehre. I.—*Das Maschinenzeichnen Zeichnen nach Vorlage und Zeichnen nach Modell.* II.—*Die Wichtigsten Maschinenteile in Zeichnerischer und Konstruktiver Hinsicht.* By RICHARD SCHIFFNER. Revised by Professor Dipl. Ing. W. TOCHTERMANN. Berlin and Leipzig: Walter de Gruyter and Co. [Price 1·25 gold marks each.]

Théorie Générale sur Les Courants Alternatifs.—By M. E. PIERNET. Paris: Gauthier Villars et Cie.

THE IRON AND STEEL INSTITUTE.

THE fifty-fifth annual general meeting of the Iron and Steel Institute commenced yesterday, and is being continued to-day at the Institution of Civil Engineers. Mr. Francis Samuelson, the retiring president, occupied the chair at the opening proceedings yesterday.

THE REPORT OF THE COUNCIL.

The report of the council, which was read by the Secretary, stated that the total membership on December 31 last stood at 2,137. During the year 1923 the deaths of twenty-seven members had been reported to the council, the number including Dr. J. E. Stead, past president; the council felt that they were but interpreting the views of the members by placing on record their deep sense of regret at the loss the Institute had experienced by the decease of that esteemed scientist.

The report then gave the names of various members upon whom honours and distinctions had been conferred during the year. It also recorded the accounts and stated that for the year under review the income was 8,095*l.*, exclusive of the Carnegie Scholarship Funds and of the interest received from the investments constituting the Special Purposes Fund; the expenditure was 8,012*l.* The figures for the preceding year, 1922, were: income, 7,964*l.*, and expenditure, 7,939*l.*

The report further recorded the alteration in the bye-law relating to the election of the president. This now read: "The president shall be elected for one year," instead of "The president shall be elected for two years and shall not be eligible for re-election until after an interval." The report concluded by stating the different bodies on which various members acted as representatives, and by recording changes in the membership of council.

Mr. Francis Samuelson then inducted into the chair the newly elected president. Sir William Ellis, who, as his first duty, presented the Bessemer medal to Professor Albert Sauveur, of Harvard University, Cambridge, Mass., United States.

Professor Sauveur, he stated, was born in Belgium in 1863, and studied first in the School of Mines, Liége. He went in his early youth to Boston, U.S.A., and entered as student the Massachusetts Institute of Technology, where he obtained the degree of B.Sc. in mining and metallurgy. He then entered, in 1889, the service of the Pennsylvania Steel Company as chemist, but left the following year, 1890, to take charge of the Research Laboratory of the Illinois Steel Company, Chicago. Here he took up the microscopic study of iron and steel. He devoted much attention to the investigation of the phenomena of crystallisation, and his work resulted in the introduction of important modifications and improvements, particularly in the rolling of steel rails. His first paper on "The Microstructure of Iron and Steel" was presented to the American Institute of Mining Engineers in 1893, and in this Sauveur showed that he had thoroughly grasped the problem of the relative effect of temperature, degree of work, rate of cooling and chemical composition on the grain size of rolled and forged products. His paper on "Microstructure of Steel and Current Theories of Hardening" still remained a landmark in the history of heat treatment, in which subject he had since always been recognised as a leading authority. Professor Sauveur had published upwards of 120 papers and articles relating to the metallurgy of iron and steel, and had been editor of several important metallurgical periodical publications. His greatest and most widely known work was his text-book on "Metallography and Heat Treatment of Iron and Steel." Since 1905, Sauveur held the position of Professor of Metallurgy at Harvard University. In 1913, he was awarded the Elliott Cresson Gold Medal of the Franklin Institute. From 1917 to 1919 he was Director of the Division of Metallurgy in the Technical Section of the Air Service of the American Expeditionary Force. In 1924, he was appointed Henry M. Howe lecturer of the American Institute of Mining and Metallurgical Engineers, of which Institute he was a vice-president. Professor Sauveur was an honorary member of the Institute of Engineers of the Liége School of Mines.

Professor Sauveur said it was a great honour to him to become one of the 57 recipients of the Bessemer Medal since its foundation, in 1874. To become also one of the smaller group of 6 American metallurgists who had received the medal in the past was a great gratification to him, for those American metallurgists had played an important part in the development of the iron and steel industry. Professor Sauveur paid a graceful compliment to British scientists; their names formed a long list, and he said he owed much to them. He expressed his pleasure at having been able to come over to the meeting, since none of his American predecessors had been able to do so on similar occasions. He could not but feel, he added, that he hardly deserved the distinction which had been conferred upon him—it would inspire him to do more.

THE PRESIDENTIAL ADDRESS.

In his address, Sir William Ellis first referred to the alteration in the byelaw, the result of which would be to enable men to reach the Chair at a reasonable age, so that they might give the benefit of their experience and useful work to the members when still in full vigour of their industrial life. Continuing, and dealing with his subject more from the standpoint of the engineer than from that of the metallurgist, Sir William compared briefly the position of a steelworks at the time he commenced active work, about forty years ago, with the state of things now ruling. In the early 'eighties of last century, he stated, the management of steelworks was in the hands of men of great common sense and great power of application, but owing to the absence of efficient means of training they were unable to deal with their practical difficulties except by common-sense methods. The steam hammers did not exceed 50 tons; four firms had, however, already put down forging presses up to 4,000 tons. The Bessemer process was in full swing, and the open-hearth furnace was already being largely developed; but a 30-ton open-hearth furnace was in those days regarded as a large one. The rolling mills were of relatively small power, they were still driven with beam engines and gear, and the direct rolling of steel rails from ingots instead of from cogged blooms had not long been introduced. Metallurgy as a science could hardly be said to exist; technical institutions for the training of students in engineering and metallurgy were only then coming into existence. Sir William could not help feeling that great credit should be given to the men of those days who, with their poor technical equipment were able to do the good work they did, and developed the industry of the country as satisfactorily as was the case.

At the present time, the Bessemer process had practically disappeared in this country; the open-hearth furnace reigned supreme, but on a much larger scale, furnaces up to 60 tons being common practice. Steel-making in electric furnaces had also been introduced. Hammers for anything but light purposes had disappeared and quick-acting forging presses had been universally adopted. To his mind, the introduction of electric driving and high-pressure steam were the two elements which had revolutionised steelworks equipment and introduced economies more than any other feature, except perhaps improved education. Metallurgy as a science, had practically been born since the earlier years he referred to, but it was a science still in its infancy, or, possibly, in early manhood. Sir William referred to the high quality of steel and steel alloys now manufactured. He voiced the regret of several members of the Council to the effect that many of the papers put before the meetings were of too scientific a nature and did not deal sufficiently with actual works problems and the difficulties arising therefrom. Quite apart from confidential matters affecting the interests of a firm there were many problems of general interest to steelmakers which could be usefully discussed at the Institute. As an illustration of recent progress in methods of manufacture, he referred to the hollow rolling process taken up by his firm for the manufacture of turbine drums, starting from a solid ingot punched or bored out. His final remarks dealt with the valuable work carried out by the British Engineering Standards Association.

INDUSTRIAL NOTES.

SINCE our last issue the Court of Inquiry has continued its sittings, during which Mr. Lee, Secretary of Mining Association, referring to the necessity of the recoupment of deficiencies to maintain the agreed relation between wages and profits, in face of the obligations to pay a minimum rate of wages when the proceeds of the industry were insufficient to provide it, said the recoupment provision had been a failure and deficiencies amounting in all to 11,250,000*l.* were wiped off on paper without any benefit at all to the owners. The main difficulty in the collieries was the reduction of output per person, chiefly due to the reduction of hours of working in 1919. If the 1913 rate of output had been maintained in 1923, the rate of earnings per shift would have exceeded that of 1913 by a percentage greater than the percentage increase in the cost of living. The increase in wages since 1914, added Mr. Lee, had been greater in the coal industry than in most of the other industries exposed to foreign competition. In 1913, the average number employed was 1,110,000 and the output was 287,400,000 tons; in 1923, the number employed was 1,150,000 and the output 279,200,000 tons. Another statement by Mr. Lee was to the effect that if wages had been paid at the cost of living figure, plus 2*s.* per shift for adults and 1*s.* for boys, for the period from October, 1921, to December, 1923, the trading loss would have been over 65,000,000*l.*

At the last sitting of the Court, the following statement was submitted by Mr. Herbert Smith on behalf of the Miners' Federation, as summing up the case for the men:—The wages paid to the workers in the collieries under the provision of the late agreement were substantially less than the equivalent of their pre-war earnings. The increase of 2*s.* per shift to adults and 1*s.* to boys under sixteen, recommended by the Coal Industry Commission in March, 1919, was, at least in part, for the purpose of raising the standard of living of the mine workers. The agreement of July 1, 1921, while giving the workmen wages less than the equivalent of pre-war earnings, allowed the owners profits substantially in excess of pre-war profits. The first charge upon net proceeds of the industry should be a minimum wage to the workmen. That minimum should include the elements composing the standard as defined in the recent agreement, but revised having regard to (*a*) the increased cost of living, as indicated by the current figures published by the Board of Trade, and (*b*) the improvement in the standard of living provided by the award of the Coal Industry Commission, 1919. Any standard profits should be at the fixed rate per ton corresponding to the pre-war profits per ton. The earnings of railway wagons and the profits from coking and by-product plants should be regarded as proceeds of the industry.

In a concluding statement, Mr. Evan Williams said the owners were anxious to give as high wages as were consistent with the carrying on of the industry in the interests of the men and the country, as well as themselves. Lord Buckmaster said, in concluding the proceedings, that all that was now left was for the Court to consider the statements and evidence, and to publish their findings. They would do this as speedily as possible, as they recognised the tremendous importance of having their pronouncement before the public at the earliest possible date.

The Coal Merchants' Federation have submitted the figures of their retail trading to Messrs. D. W. Coats West, Grimwood and Co., chartered accountants, whose certificate reads as follows:—"We have had produced to us statements, certified in each case by the auditors, of the profits and tonnages of the companies and firms with which your six members who were present at the meeting with the Secretary for Mines on March 18, 1924, are associated. We have calculated from the statements the average net profits per ton for the years 1921-22 and 1922-23, and certify them to be: 1921-22, 9·80*d.* per ton; 1922-23, 9·03*d.* per ton; the dates to which the accounts are made up in each year vary from March 31 to June 30. The figures are all shown on a comparable basis, income from investments and wagons being excluded, and no charge being made for interest on capital, remuneration of partners, directors or managing directors, income tax or corporation profits tax." The Secretary of the Merchants' Federation has stated that the figures for the current year will be published as soon as they are available.

At the annual conference of the Technical Institute held in Manchester, last week, Mr. B. Robinson, of Oldham, said that the shortage of juvenile labour in the mule-spinning section of the cotton industry was causing considerable anxiety to those who favoured a forward policy in the trade. The shortage was prevalent in the Oldham area before the war, but it has grown very rapidly since the abolition of half-time and the raising of the school-age to 14 years and the provision of greater facilities for secondary education. Mr. Robinson urged that no further attempt should be made to raise the age at which children could enter the mill until the possibilities of recent legislation had been fully developed. It had been said that child labour was wanted because it was cheap; that was not true. It was wanted because it was impossible to teach grown-ups to become efficient operatives.

The airways dispute was settled last week-end and the services were resumed last Monday. It is reported that the agreement arrived at with the pilots provides for the creation of a new post, that of air superintendent. The flying pay for pilots in future is also reported to be on the basis of the flying hour, and not on the miles, for the first six months, after which period the basis of payment is to be open for revision. There is, further, to be a superannuation scheme; each pilot will be insured for 1,000*l.* as formerly; for the first year each pilot engaged will be on a one-year contract subject to three months' notice on either side. The Federation of British Aircraft Workers have also arrived at a settlement. The skilled workers have agreed to drop a halfpenny per hour on the company's last offer on April 28 of one shilling and sixpence, for the purpose of bringing the lower grade workers a halfpenny per hour higher. Accordingly, the rates now stand at one and fivepence halfpenny for skilled mechanics, one and twopence halfpenny for semi-skilled, and one and three-halfpence for labourers, the two last sums representing an advance of one halfpenny, while the first is a drop of a halfpenny.

A crisis seems likely to arise in all the coal exporting ports of the country as the result of a dispute which has arisen among the coal tippers and trimmers at Leith. Four unions are involved in the discussions which are now taking place, namely, the Transport and General Workers' Union, the National Union of Railwaymen, the Cardiff Coal Trimmers, and the National Union of General Workers. The Leith dispute arose over the appointment of certain charge hands; a strike followed, which has now lasted about a month.

A settlement has been reached between the Traders' Co-ordinating Committee on Dock Charges, representing the Chamber of Shipping, the Federation of British Industries, and other bodies, and the railway companies, with regard to the future charges which the latter are empowered to make at the docks which they control. A statement outlining the settlement is issued by the Federation of British Industries, 39, St. James's Street, S.W.1.

The report of an interview with the Hon. E. G. Theodore, Premier of the Queensland Labour Government is given in the *Yorkshire Evening News*. Mr. Theodore states that arbitration in labour disputes has been a complete success in Queensland, where the system applies to every industry and calling within the State. The decisions by arbitration have often involved hundreds of thousands of pounds. The Arbitration Court can easily be invoked by employers or employees, either to settle a dispute or before any dispute occurs. Arbitration is accepted by the unions and employees generally and also by the employers. Machinery is available to enforce awards; their non-observance by either party is provided against by penalties.

The prospective repeal on August 1 of the McKenna duties is viewed with grave concern in many industrial circles throughout the country. The motor-car industries, among others, are most anxious with regard to the future, and several firms have been compelled to start at once taking steps to provide for the situation which is certain to follow their removal. The Sheffield steel industries will also suffer largely, as can be ascertained by a resolution which was unanimously passed at a meeting held in Sheffield last Tuesday, of representatives of 250 steel-making firms employing about 30,000 men. The resolution stated:—"That a large and representative meeting of Sheffield steel makers, held this day (the 6th inst.), having had under consideration the effect of the abolition of the McKenna duties, proposed by H.M. Government, upon the steel and allied industries of Sheffield, views with alarm the result which this action will have upon the trade of Sheffield, and considers it a duty to state that if the proposal is carried out a serious diminution in work in this district will take place, involving a still further addition to the already grave unemployment problem of the city." This resolution was forwarded to the Prime Minister, the Chancellor of the Exchequer and the seven members of Parliament for Sheffield.

Overtime, night shifts, and Sunday work in H.M. dockyards and Admiralty industrial establishments are to be governed by a revised scale of pay which has now been approved. Time worked outside the ordinary working day will be paid at time and a-half. For time worked after midnight, in continuation of work on which the same men have been employed before midnight, double pay will be granted, and also for all time worked between midnight Saturday and midnight Sunday. On holidays or days on which general leave with pay is granted for special purposes, the men, in addition to the payment of an ordinary day's wages for the holiday, will receive payment at ordinary rates for time worked, at one and a-half rates for time worked outside the ordinary limits, and at double rates if kept on after midnight. Night shifts will receive one and a-third rates, one and two-thirds rates in excess of ordinary time, and double time for work between midnight Saturday and midnight Sunday. They will also get one and two-thirds rates for work between the normal closing time on Saturday and the normal opening time on Monday, except during Sunday hours.

An acute crisis has arisen in the building trade as a result of the ballot by the men on the terms referred to in our issue of April 25 last, on page 522. The men have rejected, by a large majority, the employers' offer of ½*d.* per hour increase given in answer to the men's demand for an increase of 2*d.* per hour. Although only about 25 per cent. of the membership of the Operatives' Federation voted, the majority for the rejection of the employers' terms was overwhelming, the figures for and against acceptance being 13,462 and 104,001, respectively. The votes in favour of further negotiations with the employers, with a view to obtaining an improved offer, numbered 91,735, while 34,719 votes were recorded against further negotiations. There was also practically a 3 to 1 majority in favour of a strike in the event of further negotiations proving abortive, the figures for and against strike action being 94,104 and 32,483, respectively. The operatives, we understand, will meet the employers' Negotiating Committee on Monday next, but it is unlikely that any further concessions will be made by the employers, so that there appears to be every prospect of a strike being declared. The 14 days' notice given by the men has now expired.

LETTERS TO THE EDITOR.

SHIP'S TRIM INDICATOR AND SHOAL WATER ALARM.

TO THE EDITOR OF ENGINEERING.

SIR,—In these days of depression in the shipbuilding world, it seems like flogging a dead horse even to contemplate any minor improvements, but it has often been found that in private undertakings, a slack period is the time when new ideas are developed by the principal and his staff, which have led to the future success of the firm, as investigation can then be patiently made, for which the hurry and excitement of prosperous times would not allow leisure. Now, if and when prosperous times recur the science of shipbuilding will be called upon to meet the most severe conditions that a reviving industry will require, which will probably be in the direction of greater speed for vessels of every class, and the best means of insuring safety at sea under all possible conditions.

An important point with regard to these two qualities was emphasised a few years back by Sir Alfred Yarrow, who made many experiments showing that in the case of vessels having a speed of 19 knots and over the co-relation between speed, depth of water and the fore and aft trim of the vessel gave very useful indications by means of which the approach of shallow water could be indicated without having recourse to sounding.

A few years ago he carried out a series of experiments to ascertain the alterations of trim at certain speeds and certain depths of water, which led to his inventing a neat little instrument consisting of a series of levels set at different angles, each setting corresponding to a given speed in deep water. If at a known speed the bubble of its corresponding level were seen to rise, it would be evidence that shoal water was being approached and that soundings would have to be taken. He was informed by some naval officers in the Japanese Navy that such an instrument would have been of considerable use to their vessels in the Russo-Japanese War when chasing the enemy in thick weather or uncharted seas, where much valuable time was lost in sounding, whereas they could have chased the enemy boldly until the rise of the bubble in the instrument showed the approach of shoals.

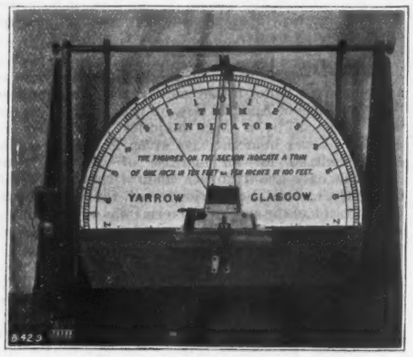
This instrument, however, gave no numerical indications, nor any warning when it was not being looked at, and an instrument that would fulfil these two conditions might prove to be of considerable use.

The accompanying illustration is a suggestion for such

an instrument in which the indications represent the swing of a pendulum about 40 ft. long, the movements of a short pendulum being magnified by means of a toothed sector and wheel. A simple arrangement enables a contact to be made with an electric bell, this contact being adjustable to requirements. While the speed of the vessel remained constant, the ringing of the bell would give a certain warning that shoal water was near.

The instrument shown is only a model made up in spare time, but any good instrument maker could, I believe, make one that would have a certain value under conditions that would occur from time to time in the case of speedy vessels.

Of, course, in a heavy sea it would be impossible to use such an instrument, as described, but every instrument has its own limitations. My immediate object



is an academical one—to draw attention to the question of the possibility of utilising the relation between speed, trim and draft of water, illustrated by the experiments made by Sir Alfred Yarrow.

Another method which would possibly be preferable to the proposed instrument would be to have a small tube (say, ¼-in. diam.) about 40 ft. long, fitted approximately horizontally along the vessel each end of the tube terminating in a larger tube (say, some 4 ft. to 6 ft. in vertical height). This could be filled with water or mercury, the height of which would give the required indications.

The object of making the vertical tubes much larger than the connecting horizontal tubes is two-fold—firstly, to minimise to negligibility the effect of any heat to which the latter might be subjected in passing through a warm section of the vessel, and, secondly, to cause the change of level to take place slowly, which would enable the readings to be taken in rough weather, especially if a restraining valve were fitted, which could be adjusted to counteract, more or less, the violence of the pitching of the ship. Of course, the run of the connecting pipe could be made to conform to any extent required to avoid obstructions.

Yours truly,

A. W. NESBITT.

"The Laverocks," Peacehaven, Sussex, April, 1924.

[The instrument was designed by Mr. Nesbitt.—ED. E.]

BRINELL INDENTATIONS.

To the Editor of Engineering.

SIR,—It is well known that Brinell numbers calculated from the diameters across the tops of the indentations usually differ from those calculated from the net depths, *i.e.*, the depths measured from the original surface of the material. This is of course owing to the ridges which generally surround the indentations, and less frequently to depression which cause the areas calculated by the two methods to differ. A further contributary, but less influential, factor is present because of the flattening of the ball.

If, moreover, indentations are made in a material with varying loads it might be predicted that the numbers would vary, for the shapes of the indentations are not geometrically similar. It has, however, been concluded by Mr. R. G. C. Batson* from tests on four materials having Brinell numbers up to about 300 that the numbers are independent of the loads if the areas are calculated from the net depths. This is confirmed by some of the curves in Fig. 1, but it is evident that there is an appreciable variation in the cases of curves numbered 1, 2, 3, 5 and 8. It is to be concluded from Fig. 1 that although the Brinell numbers calculated from the net depths are constant for some materials, there are notable exceptions.

The corresponding set of curves where the Brinell numbers are calculated from the diameters across the tops of the indentations are given in Fig. 2, and it will be noted that there is a similarity between the shapes of the corresponding curves in the two figures. There is, indeed, a definite relation between the two sets of curves, for if the areas calculated by the two methods are plotted one against the other the points will be found to lie on a series of straight lines. This is shown in Fig. 3. If A_D and A_d be the areas calculated from the diameters and net depths of the indentations respectively, then the relation between the areas is

$$A_D = a A_d + b \quad . \quad . \quad . \quad . \quad . \quad . \quad (1)$$

where a and b are constants. The values of the constants and the nature of the materials tested are given in the following table.

Fig.1. RELATIONS BETWEEN BRINELL NUMBERS (CALCULATED FROM NET DEPTHS OF INDENTATIONS) AND LOAD.

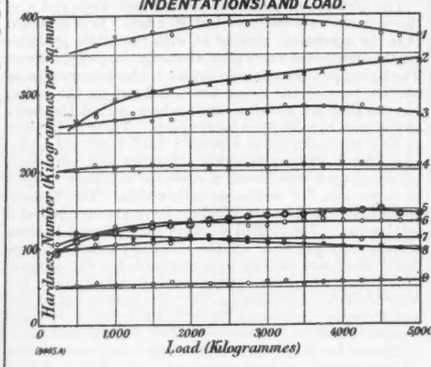


Fig.2. RELATIONS BETWEEN BRINELL NUMBERS (CALCULATED FROM DIAMETERS OF INDENTATIONS) AND LOAD.

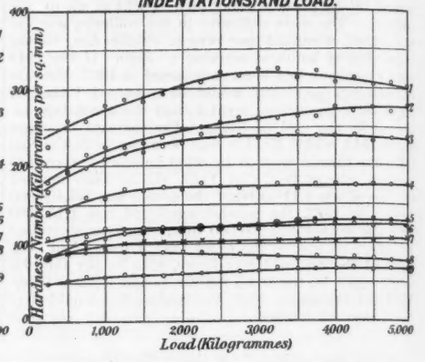


Fig.3. RELATIONS BETWEEN AREAS OF INDENTATIONS CALCULATED FROM DIAMETERS & NET DEPTHS

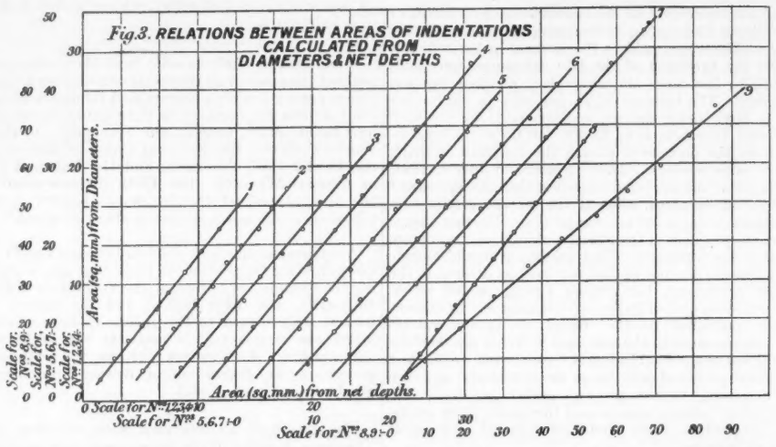


TABLE.

No. of Specimen.	Nature of Material.	Constants	
		a	b
1	A.W. tool steel (annealed) ..	1·235	0·08
2	Cast steel (unannealed) ..	1·225	0·215
3	Cast iron	1·15	0·415
4	Medium carbon steel (unannealed)	1·165	0·445
5	Mild steel (unannealed) ..	1·14	0·02
6	Wrought iron (unannealed) ..	1·075	0·25
7	Mild steel (annealed)	1·075	0·15
8	Copper (cold-rolled)	1·27	0·74
9	Cast brass	0·82	2·60

The constant a appears to be mainly influenced by what happens around the edges of the indentations. This constant is greatest in the case of the copper, and it was noted that for this material the ridges around the indentations were more pronounced than for any of the others. The constant has its least value and is less than unity in the case of the brass. For this material ridges were absent, distinct depressions being present in their stead.

The significance of the constant b is not immediately evident, for it at first appears to mean that when $A_d = 0$, A_D has a value, *i.e.*, it is equal to b. This is evidently impossible, and it is probable that an investigation with very small indentations would show that the straight lines in Fig. 3 became curved near the origin and terminated there. This may be accounted for by the probability that for very small indentations the conditions will differ from those present when the indentations become appreciable.

It will be noted from the table that the constant b is small. It can in most cases be neglected in the region of a load of 3,000 Kg. or over. The areas will then be proportional to one another. Also if H_D and H_d denote the numbers calculated from the diameters and net depths respectively and W the loads, then equation (1) can be written $\frac{1}{H_D} = \frac{a}{H_d} + \frac{b}{W}$, which becomes $H_d = a H_D$ if the constant b is neglected.

The loads were applied by an "Amsler-Laffon" oil pressure machine. The diameters and net depths of the indentations were measured with a travelling microscope and spherometer respectively, each capable of reading to one five-hundredth of a millimeter. The same Hoffmann ball, one centimeter diameter, was used throughout the experiments.

The specimens were all about 12 in. long, 2 in. wide and 1 in. thick, and were ground parallel, one face being carefully polished. The obvious precaution of testing the specimens for uniformity was taken before the experiments were commenced.

Yours, &c.,

H. CARRINGTON.

College of Technology, Manchester, April 30, 1924.

NEW ENGINEER REAR-ADMIRAL.—The promotion of Engineer-Captain L. J. Robinson, O.B.E., to the rank of Engineer Rear-Admiral is announced. Admiral Robinson has been for the past two years Assistant Engineer-in-Chief of the Navy, and for the two preceding years Engineer Manager of Rosyth Dockyard.

ROYAL INSTITUTION.—The annual meeting of the members of the Royal Institution was held on Thursday, May 1. The annual report stated that 53 new members were elected during last year, and 63 lectures and 18 evening discourses were delivered. The following gentlemen were unanimously elected for the ensuing year:—President, the Duke of Northumberland; Treasurer, Sir James Crichton-Browne; Secretary, Sir Arthur Keith.

THE INSTITUTION OF CIVIL ENGINEERS.—The council of the Institution of Civil Engineers announce that Professor Elihu Thomson, Massachusetts, U.S.A., has accepted an invitation to deliver the 30th James Forrest Lecture during a visit to this country, and accordingly the lecture, which was originally fixed for the 6th inst., has been postponed until Tuesday, July 8. Professor Thomson has been awarded, by the presidents of the eight British engineering institutions constituting the award committee, the triennial Kelvin Gold Medal for 1923; and formal presentation of the medal to him will take place during the Kelvin centenary celebration in July.

* Proc. Inst.M.E., April, 1923.

MINE RESCUE APPARATUS; EMPIRE EXHIBITION.

CONSTRUCTED BY MESSRS. GUEST AND CHRIMES, LIMITED, ENGINEERS, ROTHERHAM.

FIG. 1.

FIG. 2.

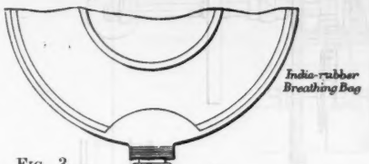


FIG. 3.

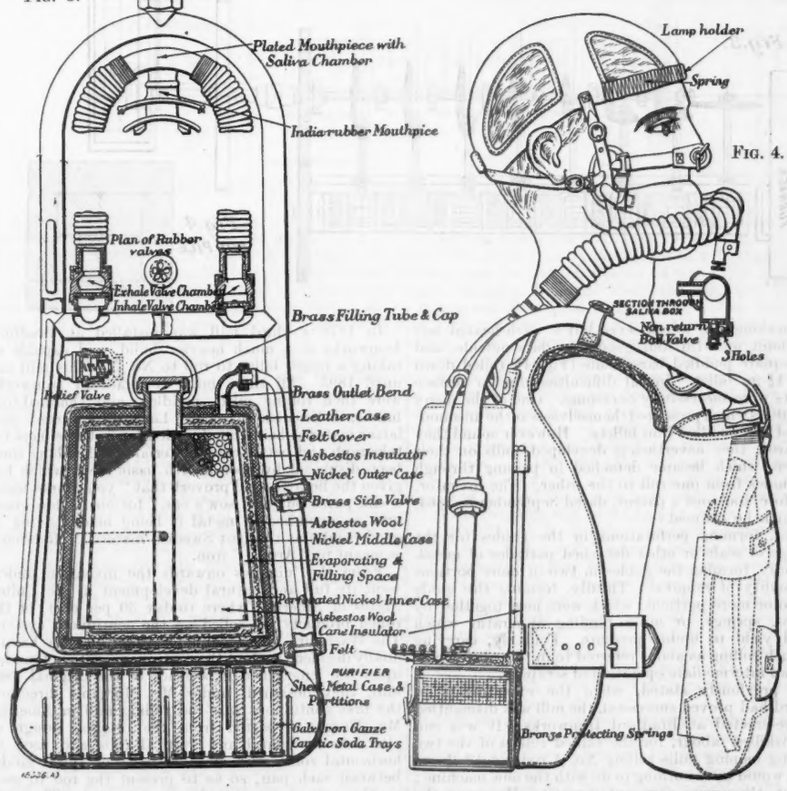


FIG. 4.

LIQUID AIR MINE RESCUE APPARATUS.

AN exhibit worthy of notice at the stand of Messrs. Guest and Chrimes, Limited, of Rotherham, at the British Empire Exhibition, is the firm's latest pattern of mine-rescue breathing apparatus. Messrs. Guest and Chrimes are the licensees and sole manufacturers of Blackett's Aerophor of the Brown Mills type, an appliance which is officially sanctioned by the Department of Mines and which is in use at nine of the most important rescue stations in this country. The apparatus uses liquid air in distinction from other types using compressed oxygen, and this offers considerable advantages in some directions as, for instance, in obviating regulation devices and hand-manipulated valves. The apparatus is illustrated in use in Figs. 1 and 2 annexed, and in detail in the line illustrations Figs. 3 and 4. The main part of the apparatus is the pack carried on the back and fitted with a liquid air container. On the back also, below the pack, is carried a purifier. Over the breast is worn a large breathing bag. The liquid air pack has two containers one inside the other, the innermost being further fitted with a perforated lining, the space inside which is filled with asbestos wool. The liquid air is poured into and is absorbed by this material. At the bottom of the inner container is a space used as an evaporating chamber, connecting with the space between the inner and outer containers. The latter is lagged with asbestos covered with felt, the whole being encased in leather. The evaporated air passes from the pack by a circulating tube to the breathing bag suspended in front, or by a flexible tube to the mouth piece, fitted with a non-return valve for the supply pipe.

The exhaled air passes from the mouth piece through a flexible tube over the left shoulder and down to the purifier below the pack. The purifier is fitted with twelve gauze wire holders filled with caustic soda which absorbs the CO_2, allowing the remainder of the gas to pass back to the breathing bag. The latter is protected by a leather bag and stiff bronze springs. A saliva box is fitted to the mouth piece. Surplus air is allowed to escape through an automatic relief valve on the exhalation side of the circuit. The whole circulation is automatic, and the hands are left free for work. The serviceable time is extended by the purification and re-use of the air, the air from the pack having to make good the losses only instead of having to furnish a completely fresh supply each time. Liquid air containing as low as 50 per cent. oxygen may be used, the flow of air from the pack at the end of 2½ hours being over 3½ litres per minute after a charge of 5½ lb. of liquid air. For two hours' use the apparatus takes 5½ lb. of air and 2 lb. of caustic soda. The weight charged is 38 lb. Starting a test with 47·2 per cent. oxygen liquid air, the CO_2 in the air being inhaled after a two hours' test, walking 4 miles per hour, was found to be only 0·62 per cent.; after 2 hours' hard work in a fume gallery the CO_2 was found to be 0·2 per cent.

THE HANDLING OF COAL AT ROTTERDAM.

IN a paper on "Modern Appliances for the Handling of Coal in the Harbour of Rotterdam," which he read before the Institution of Engineers and Shipbuilders in Scotland on a recent date, Professor F. Westendorp, of Delft Technical University, described the interesting features of the individual items of the equipment of the great port, and from this paper we have abstracted the following notes on the plant.

In the harbours there are more than sixty floating grab-cranes with lifting powers of from 4 to 10 tons. One of the latest 10-ton cranes put into service, built by Messrs. P. Smit, of Rotterdam, works at an adjustable radius of from 34½ to 59 ft., the height of the sheaves being between 95 ft. and 72 ft. above water level. Two engines are used to operate the crane, the one working to operate the grab exclusively, and the other for swinging, travelling and derricking. Another way of discharging sea-going ships is by means of bridges, of which twenty have been erected on the quays of Rotterdam and serve for the conveyance of goods to stores as well as in transhipping. These bridges are made up of a large gantry with a span of 120 ft. to 320 ft. and a folding jib extension of length up to 120 ft. jutting out over the water. Both parts are traversed by a trolley, the load on which varies from 8 to 20 tons in the different types. These bridges are mainly used for transferring cargo from sea-going vessels into Rhine ships, consequently most of the work is done on the part overhanging the water. Transport is effected along straight lines as the grab only moves in a plane perpendicular to the waterside. The grab itself can, however, be rotated about a vertical axis, the ends of the hoisting cables being fixed to a small turntable on the trolley. The type with an underhung slewing gib is also in use. It possesses the advantage of not having to travel so often due to a larger portion of the storage being covered; further, the crane driver is able to bring the grab easily to any part of the hold. Several types of grabs have been subjected to trial but only the two-cable grabs, of the Brown Hoisting Machinery Company and Demag, have given satisfaction. The former has a capacity of 400 cub. ft. carries 10 tons of coal and has a spread grabbing width of 20 ft., while the Demag bucket is of 250 cub. ft. capacity and carries 5·6 tons of coal. To obtain absolute control over the movements of the bucket in any position and at any height while working at the highest possible speed double cable grabs are necessary, and all windlasses are therefore equipped with two drums. The principal drum carries the

closing or lifting rope while the auxiliary one has wound upon it the shell rope or hanging cable.

Coaling barges are in use which have a bunker amidships from which the coal can be discharged through gates. From this bunker the coal, may be emptied at will by opening the shutters on to a conveyor running on a tunnel underneath the bunker, when it is raised on a jib on the vessel at an angle of 45 deg. up to 60 ft. or 70 ft. above water level. The coal is then allowed to fall through a receiver and telescopic shoot through a hatch into the bunker of the ship. A 5-ton revolving crane is carried on the summit of the structure, above the receiver, and is used to swing and support the shoot.

Floating elevators also find some use at Rotterdam and discharge directly from the Rhine ship into the sea-going vessel. The whole equipment is erected on a pontoon which is not self-propelled but is brought alongside the vessel. A bucket elevator raises the coal from the lighter and when the buckets pass the bend in the middle of the conveyor their contents are emptied into a trough, after which the coal is pushed by the buckets into a funnel leading to the second conveyor. The coal is then carried up to a receiver and sent through a shoot into the bunkers of the vessel. Stability is obtained by a ballast tank fed by a centrifugal pump which works continuously, filling and emptying the tanks as the circumstances demand. A pendulum is suspended in the hold and regulates the admission of steam to a Servo-motor which displaces a valve by which the suction and delivery pipes of the centrifugal pump are interchanged.

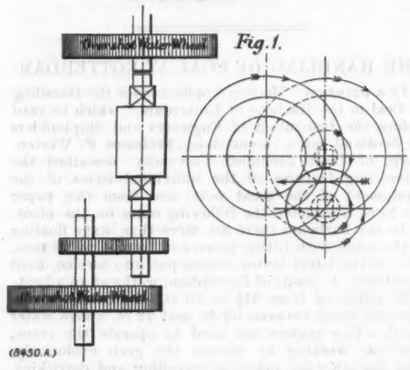
CONTINUOUS ROLLING MILLS: THEIR GROWTH AND DEVELOPMENT.*

By JOSEPH PHILLIPS BEDSON, M.Inst.C.E., M.I.Mech.E.

THE rolling-mill forms one of the most important adjuncts of a steelworks, and in considering rolling-mill practice as carried on to-day it may be of some interest to glance back for a moment to the position of the art 140 years ago. Fig. 1 shows an early mill for rolling plates for slit iron, as seen in an old ironworks in Derbyshire. It is driven by two overshot water-wheels, one wheel driving the bottom roll through spur gear, the other driving the top roll direct. This mill supplied the early nail-makers of Belper with their stock of slit rods for nails. In 1783 it occurred to Henry Cort that the usefulness of such a rolling-mill could be increased by having grooves for rolling sections, for which he obtained a patent; and from that time until the advent of the continuous system little was done beyond adding a third roll—that is, making the two-high mill into a three-high, and so saving the time and heat lost in passing back over the rolls.

EARLY PLATE ROLLING MILL IN DERBYSHIRE

Fig. 1.



(8450.A.)

With the advent of the telegraph came the demand for long lengths of wire; but the wire rod rolling-mills at that time were only able to supply single pieces of 13 to 20 lb., according to size of gauge. The material rolled was either puddled or charcoal iron, in billets of 1¾ in. to 2 in. square, and was rolled in a looping mill to wire rods of about ¼-in. diameter. These rods after being drawn to the required size, were then welded up to make long lengths, and in erection *in situ* they were spliced together with what was known as a Britannia joint; but the welded joints were ever a great source of trouble. It was under these circumstances that the late George Bedson, general manager of Richard and William Johnson Brothers, Manchester, conceived the idea of continuous rolling. He obtained a patent, dated July 2, 1862, in which he claims "the employment of a series of 'rolls' placed at varying angles, whereby the necessity of turning the metal is avoided," also the use of guides formed by spiral grooves for turning the metal to be operated upon. In a second patent of September 12, 1862, he claims "the application of rolls to a furnace, so as to draw the heated metal from it or through it."

The idea of a continuous system was suggested to him by the drawing frame in cotton manufacturing, where the cotton fibre is drawn out by successive rollers, and according as it lengthens at each draft the succeeding roller runs at an increased speed. Following out this idea he designed a series of 16 pairs of rolls placed horizontally and vertically alternately, each successive pair running at an increased speed sufficient to take up the elongation of the metal as it passed from one reduction to the other.

In 1862 this first continuous wire rod rolling-mill was built (see Figs. 2 and 3); and to avoid all works' prejudices and also to test the machine, it was erected in an old silk mill in the Adelphi, Salford, Manchester, with furnace and engine complete. It ran with such success that the inventor was encouraged to find room for it, and erected it permanently at Bradford Ironworks, Manchester, where it remained continuously in operation until 1884.

The rolling of a wire rod is one of the most difficult rolling-mill problems known; it involves the support of a very thin oval section whilst it is being rounded in the finishing pass. It must be remembered, too, that the material was anything but homogeneous. A simple puddled bar was quite out of the question, and nothing else would serve but a wash-heated box pile, built up with four good iron flats outside, and four square puddled bars inside (Fig. 4), rolled down to a 1¼-in. billet. Initial difficulties due to surface defects were successfully overcome. One of the many difficulties which presented themselves was the unsoundness of the puddled iron billets. However sound they appeared, they nevertheless developed spills on their surface, which became detached in passing through the guides from one roll to the other. The inventor, therefore, took out a patent, dated September 8, 1864, in which he claimed:—

First, forming perforations in the guides for the passage of scale or other detached particles of metal. Secondly, forming the guides in two or more portions for facility of removal. Thirdly, forming the guide in two or more portions, which were held together by clamps, springs, or other binding apparatus which would yield to undue pressure. Fourthly, carrying out such rolling as above referred to in two operations, with an intermediate operation of scraping.

As previously stated, when the experiments in Salford had proved successful, the mill was dismantled and re-erected at Bradford Ironworks. It was run by unskilled labour, for the skilled rollers of the two existing looping mills rolling No. 4 rods of 13 lb. to 20 lb. would have nothing to do with the new machine; in fact, they were very antagonistic. However, the looping mills were soon scrapped, and the works having thus "burned their boats" became dependent upon the new mill, which was capable of rolling No. 5 rods out of 1¼-in. billets 18 ft. long, weighing about 75 lb. This mill eventually rolled large quantities of best puddled iron rods to No. 8 to draw to No. 9 telegraph wire; and when it came to roll Swedish charcoal iron it did it splendidly. A second improved mill was built in 1866, which was destined to make history; for, in 1868, a replica of this mill was made for the Washburn Moen Manufacturing Company, of Worcester, Mass., U.S.A., now incorporated by the American Steel Wire Company, and the superintendent of which was the late Charles H. Morgan, who eventually became the founder of the Morgan Construction Company, of Worcester, Mass.

The original idea for the Worcester mill was to roll 1½-in. billets made out of scrap iron, "wash-heated," but the difficulties were too great; and as no suitable billets were obtainable in America, they turned to Sweden, which could furnish softer grades of iron in the form of long billets of sound material. Here the mill began to show itself. The billets were clean, with smooth surfaces, and being so highly weldable, "rolled like butter." It was Mr. W. E. Rice, afterwards president of the Washburn Moen Manufacturing Company, who was the first to see and to report to his company upon the first Bedson mill, on his visit to Great Britain in 1867. He also claimed that his firm was the first in the United States to import iron and steel direct from the Swedish manufacturers. He died on December 2, 1919, aged 86. It may be interesting to note that this mill for Worcester, with its 16 sets of rolls, housings, gearing, and a pair of high-pressure non-condensing engines to drive it, was supplied for a sum of 2,000*l.*, f.o.b. Liverpool, and the Siemens regenerative gas furnace, 22 ft. long overall, cost 1,000*l.*

Fig. 2. THE FIRST GEORGE BEDSON CONTINUOUS WIRE ROLLING MILL. 1862.

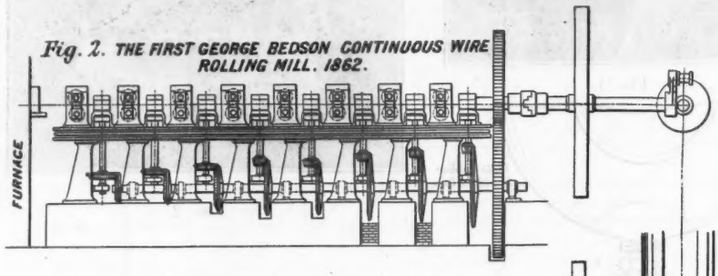
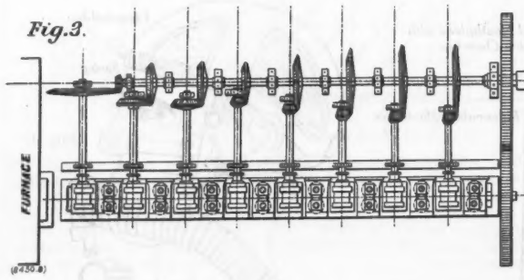
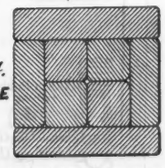


Fig. 3.



(8459.A.)

Fig. 4. BOX PILE



In 1870 a third mill was installed at Bradford Ironworks of a much heavier build, and capable of taking a larger billet to roll to No. 5. This mill ran until 1895. All these mills at Bradford Ironworks were then rolling piled, puddled, and charcoal-iron billets, or Swedish charcoal "Lancashire" iron; this latter material being much called for in those days for telegraph and better-class material. It has long since been displaced by open-hearth basic steel, which has given the lie to the old proverb that "you cannot make a silk purse out of a sow's ear." for out of low-grade ores an open-hearth metal is being made, giving as good results as the best Swedish material. Reference is meant to "Armco" iron.

From the 'nineties onwards the invention underwent its full and natural development in the United States of America, where to-day 30 per cent. of the rolled products are rolled on the continuous system. The Washburn Moen Manufacturing Company having finally decided to adopt the continuous system, founded upon the lengthened experience of the original 1868 mill, they designed, under Mr. Morgan's direction, the first continuous wire-rod rolling mill in America. Mr. Morgan departed from the original design of alternate horizontal and vertical rolls and used all horizontal rolls, with suitable twist or spiral guides between each pair, so as to present the rod to each in the correct position for compression. This mill was erected in 1878. The chief object in adopting horizontal rolls was to do away with the underground gearing for the vertical rolls, upon which the water and scale fell, causing excessive wear and tear.

The product of these mills at the outset could be wound up by hand on a simple reel, single purchase.

* Abstract of paper read before the London Meeting of the Iron and Steel Institute on May 8, 1924.

As the output increased a double purchase was used to get a greater speed; then the men could no longer keep pace and a steam-driven reel was introduced, the speed of which was regulated by a throttle and brake. It was soon found that the mill could be run at a speed beyond that at which a boy could pick up the end of the rod as it came from the last pair of rolls and stick it in the reel. The outcome was an automatic reel placed near the finishing rolls to receive the rod at the corresponding speed at which the rolls delivered it, thereby producing an evenly wound coil.

Mr. Morgan designed and patented such an automatic reel, as also Mr. Daniels; and it is entirely due to its adoption that the speed of the continuous mill is limited only by the heat due to compression, which would eventually cause the metal to melt. A 12-in. roll can be run at a speed of 1,000 r.p.m.

Little or nothing was done in this country with the system outside the Bradford Ironworks; but in 1884 La Société Anonyme de Commentry Fourchambault, Nièvre, France, ordered a mill similar to the 1866 mill, to run on a royalty, and it was built at Bradford Ironworks, under the direction of the author. The company did not, however, make a success of it, although it did roll as much as 12,000 kg. of 4 mm.

Fig. 5.

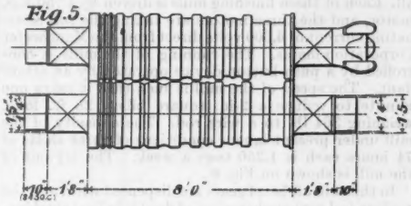
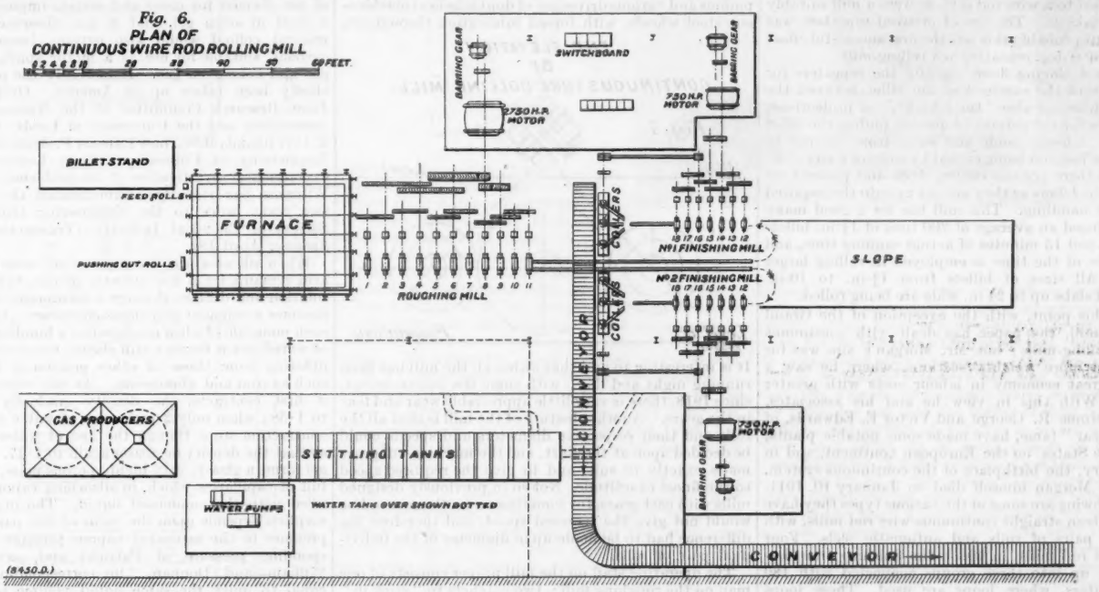


Fig. 6.
PLAN OF
CONTINUOUS WIRE ROD ROLLING MILL



(11·8 tons of No. 8), in a single shift, out of the most beautifully soft material. This was the first continuous mill to run in France. The author demonstrated at those works that it was possible to roll a billet direct from an ingot, and with the initial heat to finish it into a No. 8 wire rod. This was in October, 1885. Mr. Bedson died before this mill was finished, on December 12, 1884, at the age of 64.

In 1887 Mr. Morgan severed his connection with the Washburn Moen Manufacturing Co., and thereafter devoted himself to the development of the continuous rolling-mill system, not only for wire rods, but for billets, bars, hoops, flats, and other sections, where quantity and length were called for in the ordinary run of merchant-mill practice. But before Mr. Morgan succeeded in accomplishing these improvements, it should be noted that Mr. Daniels had also made some great advances as chief engineer of the Washburn Moen Manufacturing Company, and afterwards in the same capacity with the American Steel Wire Company.

At the same time, the 4-in. bloom was the cheapest and most available rolled product, as it could be rolled from the ingot to the size at one heat. Mr. William Garrett adopted it in his much advanced wire-rod looping mill, but he found that as his output increased, the roughing down in the three-high mill became too arduous, and he had to resort to the continuous system for this operation, which he did with success. Great credit is due to Mr. Garrett for the advance he made in the large production of the wire-rod looping mill, of which there are many in existence to-day, both in the U.S.A. and in this country.

Mr. Morgan's first type was a straight, continuous wire-rod mill, in which he adopted the 1¾-in. billet, 30 ft. long, weighing 300 lb. His company has supplied about 15 of these mills, of which one was for a Paris firm—the first of its kind on the Continent of Europe—and from that mill much of the continuous system of rolling has been copied. The author regrets he has little to say of what has been done on the Continent on these lines; but during a recent visit he has seen many continuous mills, particularly for roughing down, in conjunction with looping finishing mills, and he recalls a blooming mill rolling from an ingot to a 5-in. bloom. When cut up in suitable lengths the hot pieces could, if required, be taken to a continuous roughing train and finished into a No. 5 wire rod with its initial heat. The author is of opinion that the Germans have done more in this line than is generally known.

The question has often been asked why the 2-in. billet was adopted. In 1887 the Manchester mills were all taking 1¼-in. and 1½-in. billets, which involved buying 3-in. or 4-in. blooms and rolling them down to the sizes required; but this was an expense which close competition would not allow, and it was then that the 2-in. billet in this country was adopted, on the suggestion of Mr., now Dr., Arthur Cooper, of the North Eastern Steel Company Limited, Middlesbrough, who said: "If you can alter your mills to take a 2-in. billet, I can give you one, and thus save this reheating and rolling." His suggestion was readily adopted, and the necessary additions were made to the rod mill. He supplied a billet exact to size—a most important point for a continuous mill—and the billet had evidently been finished hot, a feat that many of our English mills are not capable of performing to-day, judging from the colour and their difficulty in keeping to a small enough size. In 1896 the 1866 mill was cut in two to allow for a loop at No. 10—there is great virtue in a loop—and six additional rolls were added at the front end of the roughing mill to take a 2-in. billet.

In 1896, Mr. N. K. Turnbull designed a rod mill for Messrs. R. Johnson and Nephew Limited, which they built themselves under his direction, and erected at Bradford Ironworks. This had eleven pairs of roughing rolls in continuous fashion—horizontally and vertically, as in the 1862 model; but the vertical drives were from above and not below. These rolls took a 2-in. billet, and after rolling it through these eleven pairs the resultant rod was finished in a looping mill to No. 6. This mill ran until 1922, when it was rolling over 400 ton a week of high carbon rods.

In 1893 the author designed a wholly continuous wire rod rolling-mill for the Bedson Wire Company Limited, Middlesbrough, since absorbed by Messrs. Dorman, Long and Company Limited, and there the 2-in. billet was adopted in a 28-ft. length, weighing 364 lb., so that, as required by some wire-drawers and others who cannot take such long pieces, the resultant rod can be cut into three equal parts of 1 cwt. each, a weight commonly called for in the wire trade.

This was a 9-in. mill, with eight roughing rolls and nine finishing rolls, set apart in parallel lines with a loop of 180 deg. It was steam-driven, and equipped with automatic reels. The author adopted the horizontal rolls throughout, with twist or spiral guides, and he owes to Mr. Morgan all the information needed to carry out this design. Its output at first was 300 tons a week from a 2-in. billet in seventeen passes—one pass being an equalising pass—to No. 6; and as the men—unskilled labour—became conversant with the running of the mill, it was to be speeded up; so that to-day this little mill is rolling upwards of 600 tons a week, with only three men on the mill itself—namely, the roller, guide cleaner, and catcher.

The adoption of the 1¾-in. billet, where there are many continuous blooming and billet mills, both as in the States and on the Continent, is very easy to account for; but for the production of this size of billet there are two or three novel "semi-continuous" rolling-mills, consisting of one pair of rolls, which takes the ingot, and, in this one pair, it is reduced at one heat to a 1¾-in. billet. A mill of this design was built by the Morgan Construction Company, Worcester Mass., and to quote the description of Mr. Jerome R. George: "This mill was designed and built for the Grand Crossings Tack Company in 1902. The owners and directors at that time consisted of two Yankees, who as young men had left Eastern Massachusetts to ply their trade of tack-makers in the west. They saved a few hundred dollars, and went into business for themselves with four tack-making machines."

From these small beginnings the company grew in a comparatively few years to a position of considerable importance as manufacturers. In addition to making tacks they took to the manufacture of wire nails; then installed a wire-drawing plant; later a continuous wire rod rolling-mill of Mr. Morgan's design and make; and, finally, a steel plant. Their plant was located in that section of Chicago known as Grand Crossings, and the company took on the name of the Grand Crossings Tack Company. The plant is now a part of the Inter-State Iron and Steel Company, having been purchased by them during the late war.

The original tack-makers' idea of a steel plant was one that would give them economically about 200 tons of 1¾-in. billets in twenty-four hours, and could be conveniently extended later into a plant producing 1,500 tons per day. Careful study of the problem indicated that the European practice of rolling 1¾-in. billets would not be suitable for American conditions; in other words, it was necessary, on account of the relatively high wage rates prevailing in the States, to employ fewer men than the European mills required, and it was also necessary, in order to approximate to the cost of rolling billets on continuous mills, to be able to roll the 1¾-in. billet direct from a large ingot and finish it in one piece, so that there would be the minimum waste in crops and shorts.

Considered in detail, the mill as finally designed was a peculiar combination of the best European and American practice. Considered as a unit, however, the mill is nothing more nor less than a standard reversing blooming mill, with a special attachment for manipulating the billet after it has become too small in cross-section and of too great length to be manipulated by ordinary means. It consists simply of a pair of rolls with the auxiliary equipment of roller tables, repeaters, bloom shears, pit furnaces, and gas-producers. Considering the economy of investment and operation, it has

demonstrated that the smallest independent producer under certain conditions can successfully compete with a large producer of many billets.

Fig. 5 is a drawing of the rolls, showing the grooves as originally designed for 15 in. by 17⅞ in. ingots. For some years now the mill has been rolling 18-in. ingots, and the grooves have been slightly modified to suit the larger ingot. Note the three duplicate finishing grooves for 1¾-in. squares. The most novel feature of the mill, of course, is the multiple repeater or set of circular grooves for conducting the billet from one pass around the housing in a spiral to the next succeeding pass. These repeaters are about 20 ft. in diameter.

The *modus operandi* is to take the ingot and roll it down—flatting and edging, backwards and forwards, by reversing until it becomes a billet of about 4-in. square. This 4-in. billet then starts on its final career, travelling round the repeaters three times. After leaving the finishing groove it passes again one-half way round the circle, and runs out at a lower level through a small trough alongside the building; the finished billet is thereby conveyed to the shear, located 475 ft. from the centre of the train. At this point the billet as delivered is so hot, due to the compression and speed at which it is rolled, that it could be still further rolled to a wire rod if there were a mill suitably placed to take it. The use of grooved repeaters was not new, but probably this was the first successful effort to employ 360 deg. repeaters in a rolling-mill.

There is a sloping floor opposite the repeaters for taking care of the overfeed of the billet between the passes. There are also "turtlebacks," or projections, on this floor for the purpose of quickly pulling the billet out of the delivery guide and away from the roll to prevent the last end being cooled by the roll water. At the shears there are the cooling beds and pockets for receiving the billets as they are cut up into the required lengths for handling. This mill has for a good many years produced an average of 200 tons of 1¾-in. billets in 7 hours and 15 minutes of actual running time, and the balance of the time is employed in rolling larger sections. All sizes of billets from 1¾-in. to 10-in. square and slabs up to 24 in. wide are being rolled.

Up to his point, with the exception of the Grand Crossings mill, the paper has dealt with continuous wire rod rolling-mills; but Mr. Morgan's aim was for higher and more weighty sections, where he saw a field for great economy in labour costs with greater outputs. With this in view he and his associates, Messrs. Jerome R. George and Victor E. Edwards, of "flying shear" fame, have made some notable plants, both in the States, on the European continent, and in this country, the birthplace of the continuous system. Mr. C. H. Morgan himself died on January 10, 1911.

The following are some of the various types they have built: Fifteen straight continuous wire rod mills, with seventeen pairs of rolls and automatic reels. Four continuous rod mills, in which the finishing train has been split up into three groups connected with 180 deg. repeaters, where loops are used. These loops are under control and do not grow appreciably, so that the exposure of each part of the rod is the same from heating furnace to finishing pass. An example of this type can be seen at Templeborough, Rotherham. A 10-in. skelp mill for producing skelp from 1⅝ in. to 8 in. in width. It is straight continuous from heating furnace to finishing stand, and flexibility is secured by introducing loops between stands after the bar leaves the roughing rolls. The finished material is cut to the required length by a rotary flying shear, delivering its product on to a cooling bed, where it is collected in piles, each representing one or two billets. A straight-through 10-in. continuous hoop mill of thirteen pairs of rolls for the production of hoop in 300-lb. bundles. Due to the compact arrangement of this mill and its high speed, the time from the heating furnace to the finishing stand is very short, making thin gauges possible. The gauge of the entire length of a 300-lb. bundle is uniform, due to uniform finishing temperature, and due to the loops that are maintained after the material leaves the roughing rolls.

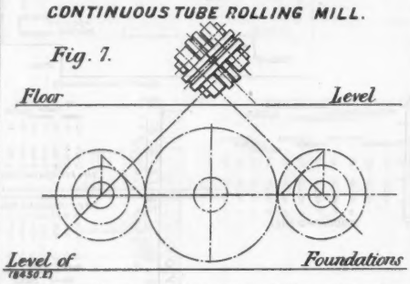
Other developments of the continuous system have been designed and made by the Morgan Construction Company, as in the following: A George staggered duo merchant mill, fed by a 30-ft. continuous heating furnace, and a six-stand 14-in. continuous roughing mill divided into two parts. An auxiliary 8-in. mill is provided, to be used until such time as conditions warrant the installation of a smaller mill, when the undesirable smaller sizes will not be a part of the schedule of this heavy mill. Skew Y-tables are only used for sizes that cannot be turned. At all other times the mill is used as a looping mill, and provision is made for loops to run over and between the tables. One more instance is a George staggered duo mill, fed by end discharge furnaces, and an interrupted continuous 16-in. roughing train. This mill is intended for rounds from 1 in. to 2½ in. in diameter, and it uses 4-in., 5-in., and 6-in. square billets in 11 ft. lengths. It also rolls flats and angles of equivalent sizes.

In 1916 Messrs. Richard Johnson and Nephew, Limited, Manchester, decided to put down another continuous wire rod rolling-mill within a few yards of where the first was erected. This was built during the war from the designs and under the direction of the author. Again, the Morgan principle of all horizontal rolls was adopted. The mill consisted of three continuous trains of rolls of 12 in. diameter. First, the roughing mill with eleven pairs of rolls, for rolling two 2-in. billets at a time, and driven by an electric motor of 2,750 h.p. Secondly, two continuous finishing mills with 12-in. rolls, each taking one of the resultant products of the roughing mill and finishing to No. 6 standard wire gauge in five passes, thus making sixteen passes in all. Each of these finishing mills is driven by a 750-h.p. motor, and the three motors are taking the full alternating current of 6,600 volts direct from the Manchester Corporation mains. The running of the mills is controlled by a push-button device operated by an attendant. The speed of the mill is such that it takes one minute to reduce a 2-in. square billet, 28 ft. long, weighing 364 lb. to a wire rod. The capacity of the mill under present labour conditions of three shifts of 7½ hours each is 1,250 tons a week. The lay-out of the mill is shown on Fig. 6.

In this mill all bevel gears are dispensed with, and the pinions and various drives are of double helical machine-cut steel wheels, with forced lubrication throughout.

END ELEVATION OF CONTINUOUS TUBE ROLLING MILL.

Fig. 7.



It is interesting to add that although the mill has been running night and day, with some few intermissions, since 1918, there is very little appreciable wear and tear in the gears. Another feature of the mill is that all the rolls and their respective diameters and speeds could be decided upon at the start, and the machine-cut gears made exactly to suit, and to give the required speed to the finest exactitude. Not so in previously designed mills with cast gears, for sometimes a tooth more or less would not give the required speed, and therefore the difference had to be made up in diameter of the individual pair of rolls.

The operating staff on the mill proper consists of one man on the roughing mill; two catchers to "stick in" in the respective finishing mill; one hooker to see to the loops; and one roller over the whole—five in all. Another unique feature is that the mill has two separate finishing trains, so that it can roll two different sizes at the same time out of the same stock. At the time of writing the mill was running No. 5 and No. 2 in equal quantities of 40 tons each size per shift, making 240 tons in the three shifts. The mill is also capable of rolling high carbon rods up to 0·80 per cent. carbon with the same facility as soft material. This is an ideal type of a wire rod mill for a works dependent upon its own rod mill for supplies, as changing sizes does not involve complete shutting down whilst changing.

To give an idea of the effect of the high speed at which the rods are finished—about 1,000 r.p.m.—a "break-out," if impeded, will run up into a solid homogeneous mass from a small section. On cutting this lump through its centre, and polishing and etching the section, it has not shown any joint or lamination whatever, even under the microscope.

There are now six continuous rolling-mills running in this country: two at Bradford Ironworks, one at Middlesbrough, two at Newport, Mon., and one at Sheffield. One of them was built by the inventor in 1866, three by the Morgan Construction Company, and the two, at Middlesbrough and Manchester respectively, were both built by the author. One recent development of the continuous system is a mill the author saw in a recent visit to Germany, which was being built for an English firm. It is called an equalising mill for tubes, and is covered by a German patent. The author was unable to obtain diagrams, but speaking from memory, the mill consisted of a train of ten pairs of rolls, placed one after the other in line. Each pair was fixed at an angle of 45 degrees to the floor line, and each alternate pair at an angle of 90 deg. to its predecessor, and each pair driven by bevel gearing at an accelerated speed to correspond with its draft on the tube. (See Fig. 7.) The author regrets he is unable to give more information of this interesting mill; but the design gets over the difficulty of the original 1862 mill of the falling water and scale dropping on the gearing below. However, it limits the rolls to one groove per roll, in contrast to the Morgan horizontal rolls, which enable a longer barrel to be used.

In conclusion, the author would like to express his thanks for all the information and assistance he has received in the preparation of this paper. First, to his old firm to whom the honour is due of being the first to exploit the continuous mill, and who have stood loyally by it for over sixty years. Secondly, to the Morgan Construction Company, of Worcester, Mass., U.S.A., and their experts, who have so splendidly developed the continuous system of rolling, not only in the United States, but in Canada, England, France, Germany, Japan and even Australia. The author is indebted to the company for the description of the system developed by them, and is delighted to present the information for publication, together with some account of his own lifelong experience.

SILICA GEL AS INDUSTRIAL ADSORBENT FOR BENZENE.

DURING the war charcoal, so far the chief adsorbent of the chemist for gases and certain impurities, found a rival in silica gel, and it was observed that this mineral colloid would also extract benzene hydrocarbons, suitable for use as a motor spirit, from coal gas and coke-oven gas. Industrially the problem has chiefly been taken up in America. Over here the Joint Research Committee of the National Benzole Association and the University of Leeds charged Mr. E. C. Williams, M.Sc., now Ramsay Professor of Chemical Engineering, at University College, London, with an experimental investigation of the problems. Professor Williams has recently communicated the results of two years' work to the Engineering Group of the Society of Chemical Industry (Transactions of the Society, April 18).

When silicates are decomposed by acids, the silicic acid remains for a few minutes in the state of a true solution and diffuses through a membrane, but it soon assumes a colloidal gelatinous character. In that jelly each molecule of silica may confine a hundred molecules of water, yet it forms a stiff elastic structure probably differing from those of other gelatinous hydroxides, such as iron and aluminium. As the silica gel dries, it first contracts, the density gradually increasing to 1·58; when only 2 molecules of water are left, the contraction stops though the loss of water continues, so that the density decreases again to 1·17. The dried gel forms a glassy, very highly porous mass, apparently full of capillaries which, in adsorbing vapours, become filled with the condensed liquid. The degree of adsorption depends upon the ratio of the partial vapour pressure to the saturated vapour pressure (the corresponding pressure of Patrick) and, according to Williams and Donnan, "for corresponding pressures equal to unity the same liquid volume is adsorbed, whatever the vapour or temperature." That rule would make adsorption a purely physical (not chemical) phenomenon and would apparently exclude preferential adsorption; in a way, it will be seen, however, the adsorption is preferential. For the stripping of vapours from coal gas the use of the silica gel offers advantages over active charcoal and also over other inorganic gels, such as iron hydroxide, which are likely to be affected by hydrogen sulphide. Some of the hydrocarbon vapours polymerise the resinous compounds which clog the capillaries; these can be burnt out of iron hydrate which then turns sluggish, however, and also out of charcoal, but not without loss of material, whilst silica may be heated to 600 deg. C., without detriment to its efficiency. In fact, some of Mr. Williams' experiments were conducted with silica gel that had so been heated 30 times. The heating is really indispensable because the adsorbed vapour is liberated again by these means.

In the first of these experiments dried air was drawn through liquid benzene and then in series through 3 U-tubes charged with the gel. All the vapour was adsorbed for about 3 hours until the gel had taken up 55 per cent. of its weight of benzene; the rate then fell off. The vapour in this case was saturated. In coal gas with about 0·8 per cent. of benzene, the saturation was only 8 per cent., and the gel then took up 13 per cent. Coal gas contains, in addition to benzene and its homologues, also pre-benzole (more condensable vapours), naphthalene, water vapour and other vapours. Of these, napthalene and moisture would be more fully adsorbed than benzene, and the question was, to what extent the adsorption of one vapour would interfere with the adsorption of another. It was found that in the presence of much moisture in benzene, the benzene initially adsorbed would be washed out again by the water vapour; the three tubes in series made the study of these features possible with other vapours. Over the ranges of commercial processes benzene, it was ascertained, can be stripped from coal gas, even when saturated with water vapour, though the gel

APPARATUS FOR PREVENTING BOILER SCALE; BRITISH EMPIRE EXHIBITION.

FILTRATORS, LIMITED, ENGINEERS, LONDON,

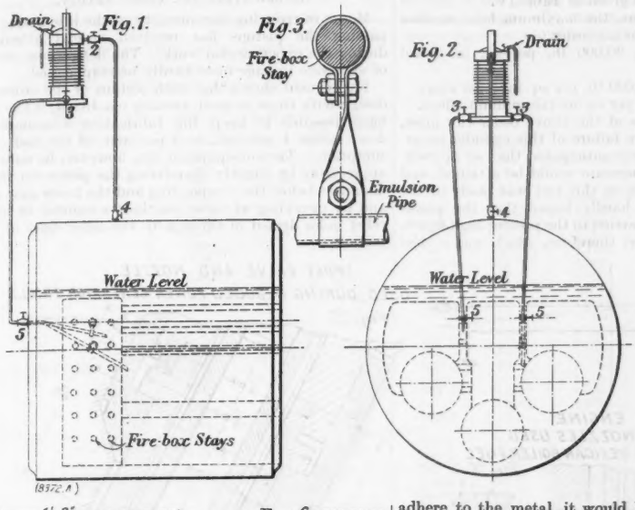
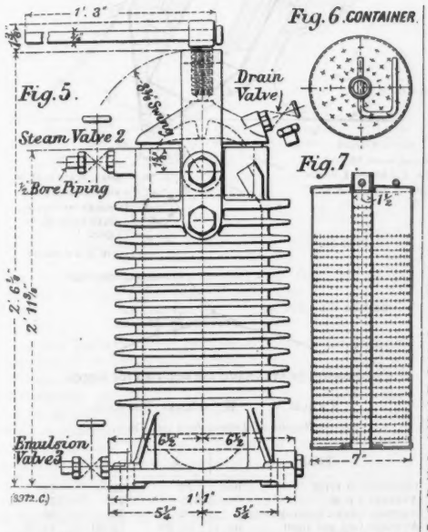


FIG. 4.



would only take up 10 per cent. (of its weight) of benzene. Since wash oils only take up about 4 per cent. of benzene, and the benzene from the gel is free from pre-benzole and naphthalene without chemical refining, the gel adsorption is certainly promising.

Mr. Williams' further investigations were carried on in America in conjunction with Mr. J. A. Reavell, of the Kestner Evaporating and Engineering Company, concessionaires of the Silica Gel Corporation, of Baltimore. In America large-scale experiments have been made for several years on vapour adsorption, and also on the treatment of liquids in several plants which Professor Williams described. The gel is finally heated in "activator" stills up to 350 degrees and to 600 deg. C. in order to recover both the adsorbed spirit and the gel. The rate of spirit recovery (97 per cent.) was excellent. But the motor spirit had an unpleasant odour and required refining in special plants, partly again with the aid of silica gel. In spite of difficulties the results obtained are considered sufficiently encouraging for planning a full-scale adsorption and refining plant in this country.

APPARATUS FOR THE PREVENTION OF BOILER SCALE.

THE consequences of using untreated sea water and other water containing salts in solution, for feeding boilers are usually disastrous. A thick hard deposit from the water coats the furnace tubes and causes the metal to be subjected to very excessive temperatures followed eventually by collapse. Were it possible to treat the water in some simple way to prevent the formation of this deposit or, at any rate, to make it come down in a form in which it does not adhere to the metal, it would be possible to do away with the extensive fresh water tanks required for boiler feed and to dispense altogether with the installation of evaporators. An interesting attempt to obtain a simple solution of this problem was made recently by the firm of Filtrators, Limited, of Cory-buildings, Fenchurch-street, London, who have now prepared designs of apparatus by means of which advantage may be taken of their proposals. The apparatus, which is shown in the accompanying illustrations, was evolved by the company and is now shown at the British Empire Exhibition on the stand of Messrs. Palmers Shipbuilding and Iron Company, Limited, of Jarrow and Hebburn-on-Tyne, who are the sole manufacturers of the plant for marine boilers.

The apparatus consists of a cast iron cylinder within which a perforated cylinder is placed which is filled with ordinary linseed and a small amount of common soda. The connections to the boiler are shown in Figs. 1 and 2, from which it may be seen that some steam from the boiler is allowed to pass into the Filtrator and there condense, extracting from the linseed the mucilage, which forms with it a sort of emulsion. This is allowed to pass continuously into the boiler through pipes leaving the base of the apparatus and passing into the water space, between the combustion chambers of the boiler. The system of support for the pipes is shown in Fig. 3 and the details of the complete outfit can be clearly seen in Figs. 4 to 7. A large and gilled radiating surface is provided for the casing to ensure rapid condensation and immediate and continuous liberation of the emulsion. Location above the boiler level is requisite, and the apparatus should be accessible and have a free flow of air around it. Once the emulsion is introduced into the boiler it mixes thoroughly with all the water and this continues as long as the Filtrator is in use. When the solids contained in the water are precipitated, the minute particles produced are acted on by the mucilage of the linseed which prevents their adherence to each other or to the surfaces of the boiler. Satisfactory working is, of course, only possible where mucilage is present in sufficient quantity. Many boilers have now been worked on this system and testimony has been made of its value. Recently, through the courtesy of Filtrators, Limited, we had the pleasure of examining one of the boilers of ss. City of Cambridge, which we were assured had then completed an 18 months' run with sea water for feeding purposes. The internal metal parts of the boiler were remarkably clean, and the only signs of deposit were apparent at the bottom of the boiler, but the matter was completely loose. Such deposit can, of course, be readily ejected from the boiler by the usual methods. An additional characteristic is claimed for the emulsion. Where there is an old deposit in the boiler, the mucilage penetrates the cracks and gets between the metal and the deposit. As it expands, it forms blisters of the old scale, and these are torn away by the circulating water. The action in every respect is said to be purely mechanical and the emulsion is harmless to the metal of the boiler and its fittings. The substance removed from the linseed is said to be only that which is soluble in water, and consequently no oil is introduced into the boiler. When necessary, the apparatus may be shut down for the removal of the perforated container and its replacement after recharging. After many tests the system is finding extensive use, and we understand that the French Government have now purchased the rights for use with the boilers of their Navy.

When this system of working is in use with fresh water only about six or seven ounces of linseed is required per ton of water, while not less than one pound should be placed in the container for every ton of salt water introduced as make up. If the boiler is not clean at the start, a full charge should be introduced into the apparatus and maintained until the boiler is free from scale. When exhausted the linseed appears dark in colour and dry, and when lightly pressed will not form into lumps. It will be seen from these statements of the requirements, that the expense entailed in the application of the system, even when sea water is used for feeding, are very small.

OPEN-HEARTH REFRACTORY MATERIAL.—According to *The Iron Age*, New York, experimental work has been started by the Bureau of Mines for the production of a high alumina refractory, using a kaolinitic bauxite as the raw material. There are large deposits of bauxite high in silica that have found a very limited field of usefulness, and these it is hoped can be utilised to produce a less acid refractory than silica, one which will at the same time have a higher fusion temperature. When such a material is fused or highly sintered, it can be made into a brick which will be practically free from the high shrinkage characteristic of bauxite brick burned at the ordinary kiln temperatures. The mineralogical composition aimed at is a mixture of sillimanite and corundum together with the eutectic formed between these two minerals. A modification suggested in the course of manufacture is the utilisation of oxygen-enriched air for the blow towards the end of the burning.

THE COLLIERY YEAR BOOK, 1924.—The complete title of this work of reference is "The Colliery Year Book and Coal Trades Directory." It is issued by the Louis Cassier Company, Limited, 34, Bedford-street, Strand, W.C. 2, at the price of 1 guinea net. Following information on the Mines Department, Mines Inspection Divisions the Mining Association and Miners' Federation, it gives particulars on the colliery owners of Great Britain, the data including the address of the firms, the list of directors, names of mines with localities, and names of managers, railway and nearest station, number of employees under and above ground, seams worked, class of coal, annual output and power used. Separate chapters deal with the Mines Regulations, the National Wages Agreement, statistics of output, prices, &c. The book also contains a collieries' who's who, a list of blast furnaces in Great Britain, of coke makers, with number and type of ovens, a list of gas works in Great Britain and Ireland, of coal merchants, &c. The book with indexes has about 1,000 pages; it is carefully got up and will prove most useful for reference purposes.

FURTHER EXPERIMENTAL WORK ON DIESEL ENGINES.*

By Engineer-Commander R. BEEMAN, C.M.G., R.N., Engineer-in-Chief's Department, Admiralty.

(*Concluded from page 591.*)

3. SHAPING OF COMBUSTION CHAMBER.

The problem of obtaining the best combustion chamber form for the reception of the injected fuel was one of the first to be faced. The essential features of such a combustion chamber appeared to be :—

(1) It should group the maximum amount of air for combustion immediately round the sprayer nozzle.

(2) The wall of the chamber opposite the sprayer should be the same distance at all points, from the centre of the fuel nozzle, in order to facilitate the directing of the jets so as to secure complete diffusion of the fuel throughout the combustion space.

These considerations naturally led to the adoption of a hemispherical depression in the piston head to serve as a combustion chamber (see Fig. 4, page 590 *ante*), the centre of the hemisphere being located at the centre of the sprayer nozzle. It is considered that the favourable grouping of the air around the fuel nozzle has contributed in no small measure to the attainment of the high mean pressures recorded in the Digit engine.

It will be appreciated that, with a combustion chamber shaped as shown in Fig. 4, and the linear clearance of the piston reduced to comparatively fine limits, the condition outlined in (1) is fulfilled. Also with regard to (2), the hemispherical depression in the piston head ensures that the maximum depth of the air in the combustion chamber, from the nozzle, is the same at all points. This facilitates the spraying of the fuel, as each jet has to penetrate the same depth of air. Importance is attached to a further feature possessed by this form. Assuming that the injection of the fuel commences somewhat before the piston reaches the top of its stroke, the air outside the fuel jets, above the flat portion of the piston, is driven inwards across the jet into the depression during the completion of the stroke, thereby greatly assisting in the intermixing of the fuel and air. Additional impetus is given to turbulence of the air charge on the return stroke by the reversal of these air currents.

The significance of the points referred to in (1) and (2) receive special emphasis, when contracted with conditions obtaining in some possible forms of combustion chamber, as for example those in Fig. 18, where a flat-top piston is indicated. Here the air is not uniformly disposed with reference to the fuel nozzle, and the possibility of efficient spraying and the mixing of the air and fuel seems doubtful in a highly rated design. This is perhaps an extreme case, but the criticism applies to some extent to any shallow (in the direction of the nozzle axis) form of combustion chamber.

4. RATE OF HEAT FLOW AND ITS ATTENDANT STRESSES.

Amongst the difficulties attending the development of high mean pressures is that of accommodating, without excessively stressing the parts exposed, the resulting high rate of heat flow through the walls of the combustion chamber. Even in engines developing moderate mean pressures the heat stresses in the parts comprising the combustion chamber may be of a very high order, if careful attention is not given to the design. Evidence of this is found in the numerous cases of cracked cylinder covers and pistons which come to notice.

For an engine designed to develop high mean pressures, it follows therefore that the design of cylinder liner, cover and piston, requires very critical consideration if they are to withstand successfully the severe conditions under which they are intended to operate.

When designing the Digit engine in 1918 the importance of this aspect was borne in mind, and some special cooling features were introduced. In particular, attention was directed to the more efficient cooling of the head of the cylinder liner than is usually the case in the ordinary engine, and provision was made by circulating the cooling water in direct contact with the liner head.

Of the stresses obtaining in the three important members comprising the combustion chamber, viz., cylinder head, liner and piston, those due to the heat flow are, at the heavier loads, greatly in excess of those resulting from the combustion pressure.

The necessity, however, for considering the probable effect of the combined operation of these two stresses is obvious. Whilst an accurate forecast of the heat flow stresses is not possible, certain deductions can be made, based on the ascertained heat transmitted to the cooling jackets of the members concerned, whereby the distribution of the heat flow may be assessed approximately, and from such approximation some indications of the stresses to be expected may be calculated.

A heat balance sheet drawn up from a six-hour test on the Digit engine when developing 142 lb. mean pressure at 390 r.p.m. is given in Table IV.

From such calculations, the maximum heat stresses appear to be of the following order :—

In cylinder cover, 30,000 lb. per sq. in. (steel casting).

In cylinder liner, 9,000 lb. per sq. in. (cast iron).

In piston, 9,000 lb. per sq. in. (aluminium alloy).

The fact that stresses of the above order can arise, derives support from the failure of this cylinder cover. In the design stage it was anticipated that an appreciable advance in mean pressure would be attained, and although some provision to this end was made in the cylinder cover, it was hardly hoped that the power development would be carried to the present high figure. The failure of the cover, therefore, which was a steel casting, was not altogether unexpected, and the new design will embody special features to meet the higher mean pressures now found possible of attainment.

The liner of this engine has proved suitable for the higher powers. In view of ultimate developments, however, the Laboratory is taking what may perhaps be regarded as anticipatory measures in testing a forged high-carbon steel liner in the Unit engine. The head portion, being of the same diameter as the cast-iron liner that it has replaced, is heavier than necessary, but the body thickness is much less, and as a result a considerable reduction in the stresses due to the heat flow is effected. It is expected, and so far has been confirmed by tests, that the steel liner will also afford marked relief from the excessive wear that often obtains in cast-iron liners in the vicinity of the head. Up to the present date the steel liner has given very promising results, and, should further running justify expectations, this type of liner will afford considerable scope for high duty work as well as for replacing cast-iron liners that are found to wear badly.

The behaviour of the Digit aluminium alloy oil-cooled piston has already been referred to, and it will suffice to remark that it is anticipated that increased thermal loading can be carried by it.

As a further step in increasing the power developed in the cylinder to very high limits the possibilities of supercharging have not been overlooked. Up to the present time, however, it has not been possible to carry out supercharging tests in the Digit engine.

The earlier experiments on the Unit engine justified the expectation that by this means the attainment of a higher power per cylinder may be advanced a further stage, and this research will follow logically when the possibilities of increasing the mean pressures by direct means are fully exploited, and further experience becomes available of the improvements in the design of the members exposed to heat stress.

LUBRICATING OIL CONSUMPTION.

Means of reducing the quantity of the lubricating oil passing the pistons has received special attention during the experimental work. The deleterious effects of excessive leakage need hardly be emphasised.

Experiment shows that with pistons of the ordinary design with rings in good working condition, it has not been possible to keep the lubricating consumption down below 4 per cent. to 5 per cent. of the fuel consumption. The consumption can, however, be reduced appreciably by slightly chamfering the piston for short distances below the scraper ring and the lower gas ring, and by providing at these positions a number of small relief holes drilled in through to the inner sides of the piston.

Prolonged running of the several engines with this arrangement has demonstrated that the consumption can be kept down to about 1½ per cent. of the fuel used. Experience with other devices suggested, as, *e.g.*, chamfering of the scraper ring to allow it to pass oil on the upward stroke and remove it on the downward stroke, has not proved them to possess any material advantage.

It may be of interest to note that in the Unit engine direct cylinder lubricating feed is not employed, it having been found that splash from the moving parts is sufficient.

Typical results from a series of carefully conducted lubricating oil-consumption trials on the "H" Class engine, with all conditions similar except for a variation in the amount of direct cylinder wall lubrication

Fig. 18.

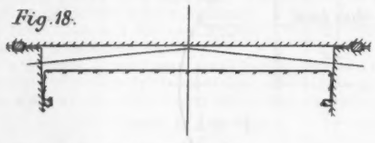


Fig. 19. "H" CLASS ENGINE SPRAY VALVE AND NOZZLES USED DURING TRIALS WITH MEXICAN BOILER FUEL

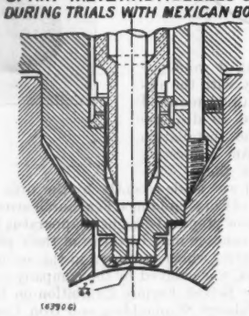
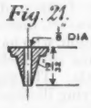


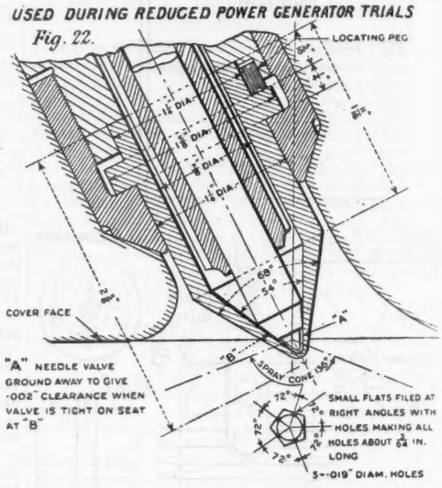
Fig. 20.

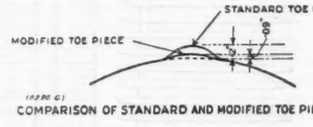
Fig. 21.



SPRAY VALVE AND NOZZLE USED DURING REDUCED POWER GENERATOR TRIALS

Fig. 22.


LOCATING PEG
COVER FACE
"A" NEEDLE VALVE GROUND AWAY TO GIVE ·002" CLEARANCE WHEN VALVE IS TIGHT ON SEAT AT "B"
SPRAY CONE 150°
SMALL FLATS FILED AT RIGHT ANGLES WITH HOLES MAKING ALL HOLES ABOUT ⅛ IN. LONG
5-·019" DIAM. HOLES



COMPARISON OF STANDARD AND MODIFIED TOE PIECES

TABLE IV.—HEAT BALANCE OF DIGIT ENGINE.

Mean Pressure 142 lb., r.p.m. 390, i.h.p. 442.
Calorific Value of Fuel : Higher, 19,300 ; Lower, 18,100 B.Th.U.

Heat Supplied.		Heat Accounted for.		Percentage.
B.Th.U. per min.		B.Th.U. per min.		
By fuel ..	38,480	Brake horse-power ..	14,255	36·7
By air ..	330	Mechanical friction..	4,450	11·5
		Jacket and cover ..	4,850	12·5*
		Exhaust valve ..	545	1·4*
		Piston cooling oil ..	1,050	2·7*
		Exhaust gases ..	12,225	31·5
		Radiation, &c. (by difference) ..	1,435	3·7
Total	38,810	Total	38,810	100·0

* 16·6 per cent. total loss to cooling media at engine.

TABLE V.—"H" CLASS ENGINE.

Results of Lubricating Oil Tests.

Trial.	1.	2.	3.
Duration of trial.. .. hrs.	72	72	72
Average r.p.m.	375	375	375
Average brake horse-power ..	30	30	30
Average fuel per hour .. lb.	12·69	12·61	12·64
Fuel per brake horse-power/hour (excluding compressor) lb.	0·423	0·420	0·421
Blast air pressure .. lb.	950	950	950
Temperature of exhaust °F.	602	608	603
Compression pressure .. lb.	490	490	490
Initial pressure .. .. lb.	620	620	620
Loss of crankcase oil .. lb.	16·1	8·7	10·20
Cylinder wall oil supplied lb.	1·4	5·3	3·55
Total lubricating oil consumption .. .. .. lb.	17·5	14·0	13·75
Lubricating oil consumption per hour .. .. .. lb.	0·243	0·195	0·191
Lubricating oil/fuel oil per cent.	1·91	1·55	1·51
Bearing oil pressure lb. sq. in.	7	7	7
Flash-point at commencement of trial .. .. .. °F.	392	393	388
Flash-point at end of trial °F.	393	388	390
S.G. at 60 deg. F. at commencement of trial	0·897	0·896	0·896
S.G. at 60 deg. F. at end of trial	0·896	0·896	0·897
Viscosity at 60 deg. F. at commencement of trial .. secs.	1,430	1,530	1,530
Viscosity at 60 deg. F. at end of trial .. .. .. secs.	1,530	1,530	1,630

* Abstract of paper read at the Spring Meeting of the Institution of Naval Architects, April 11, 1924.

supplied, are shown in Table V. At the end of the first trial some of the piston rings were gummed; after the second trial they were all free, and on the completion of the third, two rings were partially stuck. It appeared necessary, therefore, in this particular engine to supply a certain quantity of direct feed, and this had been confirmed subsequently in other tests.

TABLE VI.—"H" CLASS ENGINE.

Results of Trials with Various Oils.

Oil.	R.P.M.	B.H.P.	Fuel in lb. per B.H.P./hr.
Shale	376	30·1	0·407
	341	22·4	0·406
	297	14·9	0·421
	237	7·5	0·466
Texas	375	30	0·426
	341	22·5	0·422
	299	15·1	0·446
	236	7·5	0·494
Palm	375	30	0·489
	345	22·7	0·482
	297	15	0·507
	240	7·6	0·577
Mineral lubricating ..	373	29·8	0·446
	343	22·6	0·427
	300	15·1	0·439
	235	7·5	0·517
Mexican	377	30·1	0·426
	342	22·5	0·421
	300	15·1	0·447
	245·5	7·8	0·575

Properties of the above Oils.

	S.G. at 60° F.	Flash-point ° F.	Viscosity at 60° F. (50 c.c.).	Calorific Value. B.Th.Us. per lb.
Shale	0·877	196	56 secs.	19,200
Texas	0·928	212	536 secs.	19,300
Mineral lubricating	0·884	378	876 secs.	19,948
Mexican ..	0·943	278	3,217 secs.	18,717

Palm oil—S.G. at 105 deg. F. (liquid) ..	0·897
S.G. at 60 deg. F. (semi-solid)..	0·923
Melting point	64 deg. F.
Flash point	352 deg. F.
Viscosity at 110 deg. F. ..	135 sec. (50 c.c.)
Calorific value	16,700 B.Th.Us.

The maximum amount supplied was three drops per minute through a mechanical lubricator.

ALTERNATIVE FUELS.

In the Naval service provision is made for separate supplies of suitable oil for use in oil engines and the ordinary fuels supplied for use under boilers are not customarily supplied. Necessity or convenience may on occasion entail other fuels being employed, and while a considerable amount of scattered data is available from the Fleet and elsewhere, it was judged desirable to exploit the possibilities of other types of potential fuels in the Laboratory to obtain complete and reliable data for guidance. Experiments have accordingly been carried out on the small "H" Class engine, and comparative trials have so far been carried out with shale, Texas, palm, mineral lubricating, and Mexican oils. In this design the compressor for the blast injection air is separately driven, and in Table VI which gives results, no correction has been made for the consumption for this detached unit. The fuel-injection valve is of the simple Diesel type, *i.e.*, fitted with pulverisers near the base of the spindle and a single orifice for the passage of fuel and air into the cylinder.

In carrying out the foregoing experiments it was desired to maintain all fittings on the engine similar to those used for the shale oil trials, and beyond the provision of heating arrangements for the palm and Mexican oils it was not found necessary to make any modification, with the exception of a special type of sprayer cap in the case of the last-named oil. Subsequently this sprayer cap has been found satisfactory with other fuels.

The shale and Texas trials were run to afford a basis for comparison and call for no special remarks. In the case of the palm oil trials it was found that the best results were obtained with a fuel temperature of 95 deg. F. at the pump, and the trials given above were all run at that temperature.

As regards the mineral lubricating oil trials, the engine started readily from cold with this fuel, but was rather unsteady at the quarter-load trial, requiring continuous hand adjustment. The exhaust was not clear on any of the trials run with this fuel, but it improved towards the completion of the six hours' full-load trial.

In the Mexican fuel trials it was found that, contrary to generally accepted practice, no advantage seemed to be obtained by heating the fuel, and it was therefore concluded that heating alone could not be considered the solution of effective burning in a small high-speed engine, and it was necessary to experiment with varying forms of nozzles. The type shown in Fig. 21, page 624, was found the most suitable in that it presented no surface in the immediate vicinity of the orifice to which the deposits could attach themselves and so form a nucleus of the growth which choked the sprayer in the ordinary design. By this means the full area of discharge has been found to be always preserved, but carbonisation on the sides of the piston at the top and sticking of the piston rings have not yet been satisfactorily overcome, and these matters are still being investigated. Particulars of the trials and of the fuels are shown in Table VI.

VARIABLE LOAD TRIALS.

The Unit engine has been for some time reserved to investigate matters arising in connection with the submarine engines of the standard type. In particular, a series of trials has been carried out to determine the most suitable modifications to adapt surplus parts of this standard design for the construction of electric generating engines for other services. For these trials the engine was fitted with the standard submarine type cylinder cover, in which the spray valve is inclined at an angle of 26½ degrees to the vertical and fitted with the standard solid injection spray valve, fuel pump, scroll cam, &c. In one set of trials it was stipulated that the maximum power to be normally developed in the single cylinder was to be 50 brake horse-power at 300 r.p.m., with an overload of 55 brake horse-power at the same revolutions. It was desired that a range of powers from zero brake horse-power to the maximum could be obtained without alteration of the timing gear, and that the governing devices should operate the fuel pump suction valves. All tests were therefore made at a fixed timing gear set for 55 brake horse-power with a maximum combustion pressure of 630 lb. per sq. in.

The timings were :—

Air valve—
Opens .... 20 deg. B.T.C.
Closes .... 42 deg. A.T.C.

Exhaust valve—
Opens .... 124 deg. A.T.C.
Closes .... 24 deg. A.T.C.

Fuel valve—
Opens .... 18 deg. B.T.C.
Closes .... 8 deg. A.T.C. } at 55 B.H.P.

It was found necessary, however, to arrange for a slight movement of the fuel cut-out lever to restrict the lift and period of opening of the fuel valve. The movement necessary gave the timing of the fuel valve at no load as opening at 14 deg. B.T.C. and closing at 5 deg. A.T.C., the roller clearance changing from 0·004 in. on load to 0·038 in. at no load.

A smaller lift was found necessary and the fuel cam toe-piece had a rise of 0·09 in. only as compared with 0·2 in. on the standard engine.

Various sizes and numbers of holes in the spray nozzle of standard type were tried, but that found most suitable is shown in Fig. 22, page 624. This design, in association with the special toe-piece, gave good results when using either Texas or shale fuel oils, and eliminated the trouble due to "dribble" carbon that was experienced with other types which permitted the trapping of fuel between the valve seat and spray orifices. A seven hours' test at no load with the engine running at 300 r.p.m. was made, and no difficulty was experienced in carrying the 55 brake horse-power load immediately on the conclusion of the test.

To obtain the best results with a minimum of detonation it was necessary to adjust the compression to 480 lb. per sq. in. The more satisfactory general behaviour and results with this compression as compared with 360 lb. per sq. in. can be seen from the results shown in Table VII. The colour of the exhaust varied from invisible to very slightly shaded throughout the trials.

TABLE VII.—UNIT ENGINE.

Reduced Power Trials at 300 r.p.m.

R.P.M.	B.H.P.	Fuel Oil. Pressure.	lb./hour.	lb./B.H.P. hour.	Description.	Remarks.
		lb./sq. in.				
301·5	55·5	4,750	22·0	0·397		Compression 480 lb./sq. in. Maximum pressure 630 lb./sq. in. Exhaust: Invisible to very slightly shaded.
300·8	50·2	4,500	20·06	0·400	Texas. S.G. at 60 deg. F. 0·928. Flash-point, 212 deg. F.	
301·0	40·1	4,750	16·62	0·415		
299·6	30·0	4,750	13·53	0·451		
300·4	20·0	4,500	10·69	0·535		
299·5	10·0	4,500	7·37	0·738		
300·0	0	4,500	6·44	—		
301·0	55·2	4,750	21·5	0·390		Test run after zero trial.
300·0	55·0	4,720	23·25	0·423	As above	Compression 360 lb./sq. in. Maximum pressure 630 lb./sq. in. Exhaust: Invisible to slightly shaded. Detonation evident during all trials and the running was unsteady at the low powers.
300·0	50·0	4,500	20·59	0·412		
298·0	39·8	4,500	17·2	0·432		
300·0	30·0	4,500	13·13	0·438		
305·0	20·3	4,500	10·94	0·54		
301·0	10·05	4,500	8·44	0·839		
300·0	0	4,500	6·34	—		
300·5	55·2	4,000	21·36	0·387	Shale. S.G. at 60 deg. F. 0·877. Flash-point, 196 deg. F.	Compression 480 lb./sq. in. Maximum pressure 630 lb./sq. in. Exhaust: Invisible to very slightly shaded.
299·2	49·9	4,000	19·5	0·390		
302·8	40·3	4,250	16·43	0·408		
303·5	30·4	4,000	13·06	0·431		
302·4	20·15	4,000	10·47	0·520		
302·2	10·09	4,500	7·4	0·734		
298·5	0	4,500	5·43	—		
300·0	55·0	4,250	21·62	0·394		Test run after zero trial.

The thanks of the writer are due to the Staff of the Admiralty Engineering Laboratory for assistance in the preparation of the paper, particularly for the description of the experimental work.

AUTOMOBILE CONGESTION AND THE JAPANESE EARTHQUAKE.—Automobile congestion in Yokohama and Tokio contributed to the disastrous effect of the earthquake of last September, according to Dr. T. A. Jaggar, Director of the Hawaiian Volcano Observatory of the United States Bureau. Dr. Jaggar's statement, says *Engineering News Record*, is to the effect that the streets of the two cities were full of moving and parked cars at the time of the earthquake, and as most of the streets are old and narrow the cars largely blocked traffic in the earthquake panic. The automobiles became so jammed that fire apparatus could not get through. Dr. Jaggar adds that hundreds of gasoline-filling stations provided fuel for many fires as well as the separate tanks of gasoline in each car. It was this condition, as much as the earthquake itself, which made the Japanese disaster the greatest of all such horrors on record. He considers it only a question of time when the increasing problem of automobile traffic will require all large cities to provide special parking areas or buildings for automobiles, and not allow any machine to stand in the street without a driver at the wheel.

CORROSION OF MUNTZ METAL BY SEA WATER.—The Public Works Department of New Zealand having been troubled by the rapid disintegration of some Muntz metal sheathing above low water on Otaika Bridge, W. Donavon, M.Sc., and T. E. Perks, of the Dominion Laboratory, Wellington, investigated the matter by experimenting with various used and unused samples of Muntz metal, sheath metal and bolts of different ages. All the corroded alloys were found to be rich in copper, the worst specimens containing 67 and nearly 70 per cent. of copper and about 32 and 29·5 per cent. of zinc; the other constituents, up to 1 per cent. of lead, less than 0·25 per cent. of tin and of iron, with traces of manganese, did not appear to have any influence on the corrosion. The heat treatment of the alloy seemed to be the most important factor. Untreated Muntz metal would contain the crystals both in the α and the β phase, the α predominating generally; at 600 deg. the α would pass into the β (transition stage); at 800 deg. little of the α phase would be left. The predominance of the β phase would favour corrosion. A large proportion of inter-crystalline β in the α crystals would cause exfoliation and corrosion. Metal that had been in the transition stage seemed to be the least corrodible. The absence of uniform practice as to heat treatment and its control in various works would account for the occasional failures of Muntz metal, but its complete disintegration at Otaika within two years was exceptional, and is ascribed by Perks (Journal of the Society of Chemical Industry, March 28) to the brackish character of the water and to the electric potential differences of the alloy in waters of varying salinity. The bridge is near the mouth of the Hutt river, and the salinity of the water was found to rise from 1·5 to 3·0 per cent. in the shallow tidal water within a depth range of 20 ft.; in spite of the stormy weather the layers of different salinity did not mix.

DOMESTIC WATER-SOFTENING PLANT.

MOST natural waters are more or less hard and when the supply is drawn from wells in chalk or limestone districts, the hardness is often sufficient to make the soap-destroying and kettle-encrusting properties of the water a matter of considerable inconvenience to the domestic user. The utilisation of the properties of zeolite for water softening has now made it practicable for the householder to provide himself with perfectly soft water for washing and other purposes, and water-softening apparatus for domestic use has become by no means uncommon. The simplicity of the zeolite process and the independence of the plant of any chemicals or material other than common salt, render it especially adaptable to household purposes. Since the introduction of the process, the natural zeolites originally used have been much improved upon, and artificial zeolites are now prepared of a far greater efficiency and rapidity of action than the natural product.

Zeolite is a complex silicate of aluminium, sodium, potassium, calcium, magnesium, &c., which has the peculiar property that, when brought into contact with hard water, a chemical interchange takes place, the calcium and magnesium which give hardness to the water being abstracted and replaced by sodium or potassium which do not cause hardness. Naturally, in time the material becomes exhausted and incapable of further action. It can be revivified, however, by passing through it a fairly strong solution of common salt, when the reverse action takes place, the salt removing the calcium and magnesium from the zeolite and replacing them by sodium, thus restoring the substance to its original condition.

The apparatus illustrated in Figs. 1 and 2, annexed, represents a domestic water-softening plant, manufactured by the Kennicott Water Softener Company, who are incorporated in the firm of Messrs. John Thompson Water Tube Boilers, Limited, of Wolverhampton. The plant can be directly connected to a water-main under pressure. The water supply enters at the pipe A in Fig. 1 and passes upwards through the vertical external pipe and falls on to the bed of zeolite from a distributing device. It passes down through the material and out through a strainer at the bottom, rising again in the vertical pipe and leaving the apparatus at C. The salt solution for regenerating the zeolite is contained in the small tank at the head of the apparatus. When the time comes for regeneration, the inlet water is shut off and the other cocks so manipulated that the salt solution flows down the pipe B, enters the bottom of the apparatus, passes up through the zeolite and eventually to waste by the pipe D. It will be seen that there are no moving parts and as no sludge is formed, the plant requires no attention whatever beyond the periodical regeneration of the material as just mentioned. Larger units on the same principle are manufactured by the Kennicott Water Softener Company, for laundries, bleachworks, dye-works, &c., where water of zero hardness is required. The apparatus described is shown by the makers at the British Empire Exhibition.

CATALOGUES.

Electric Fittings.—Messrs. Donovan and Co., 47, Cornwall-street, Birmingham, have sent us an illustrated price list of fittings and materials for electric lighting.

Electric Motors.—A 36-page priced list of electric motors, generators and fittings in stock has been received from the Swedish General Electric, Limited, 5, Chancery-lane, London, W.C.

Galvanometers.—A card illustrating three types of galvanometers has been received from the Cambridge and Paul Instrument Company, Limited, 43, Grosvenor-place, London, S.W.1.

Centrifugal Extractors.—A circular illustrating ten types of centrifugal extractors, for various kinds of work, has reached us from Messrs. Manlove, Alliott and Co., Limited, Nottingham.

Railway Signals.—A catalogue of electric and electro-pneumatic signals and train stops, to hand from the Westinghouse Brake and Saxby Signal Company, Limited, 82, York-road, King's Cross, London, N.1, contains much up-to-date and useful information on the subject.

Electric Cables.—We have received a book of thirty large illustrations of electric power stations, railway tracks, crossings, tunnels, etc., in the United States which have been equipped with the cables, wires, tapes, etc., manufactured by the Okonite Company, Passaic, N.J., U.S.A. The book is an excellent example of the printer's craft.

Pyrometer.—The Foster Instrument Company, Letchworth, have sent us a catalogue of their optical pyrometer with patent lamp-bridge unit. This pyrometer is of the disappearing-filament type and is capable of giving rapid and accurate temperature measurements. The notes in the catalogue are clearly written and will be of practical interest to users.

DOMESTIC WATER SOFTENING PLANT.

CONSTRUCTED BY THE KENNICOTT WATER SOFTENER COMPANY, WOLVERHAMPTON.

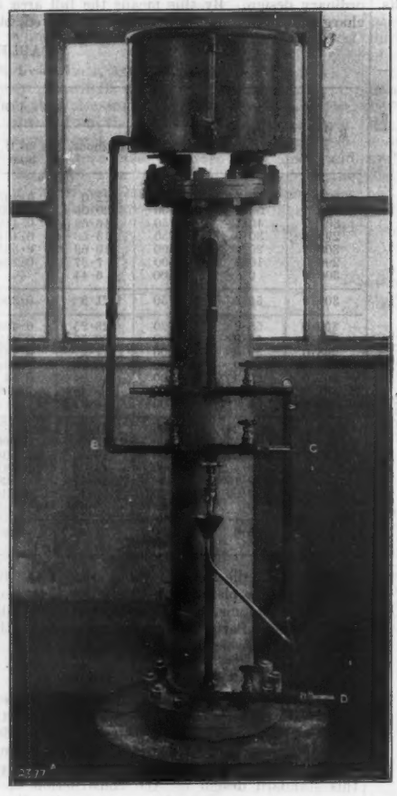


Fig. 2.

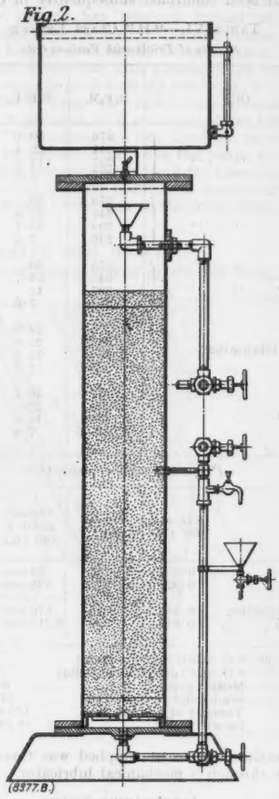


FIG. 1.

Case Hardening.—A catalogue of case hardening compounds, pots suitable for the process, pyrometers, and a paint for application to parts which are not to be hardened is to hand from the Durite Company, Limited, 30, Shepperton-road, London, N.1. Some useful notes on the operation of case hardening are included in the catalogue.

Lifting Machinery.—A little book of forty pages containing extracts and illustrations from their general catalogue which has been issued by Messrs. Holt and Willetts, Cradley Heath, shows examples of electric passenger and goods lifts, hoists, overhead travelling cranes, jib and derrick cranes, chain and wire rope blocks, jacks, etc They are operated by steam, electric or hand power.

Alternating Current Motors.—A third edition of Mr. T. Harding Churton's handbook of notes on alternating current and induction motors has been issued by Messrs. T. Harding Churton and Co., Limited, Leeds. The notes include explanations of the terms used, information as to the choice of motor for various duties and instructions relating to installation and running. The book extends to 68 pp. octavo, and is priced at 2s.

Miners' Baths.—A catalogue showing plans and appliances for pithead washing baths for miners, received from Messrs. Gummers, Limited, Rotherham, states that the cost of a bath house to accommodate 100 men at a time, or 1,000 per hour, is about 9,000*l*. The baths are showers operated by stepping on to a footboard, and the equipment provides for varying temperatures of water with a device to prevent the possibility of scalding. The firm, we may mention, specialises in the design and equipment of these baths.

Electrical Machinery.—Five publications received from Oerlikon, Limited, 34, Norfolk-street, Strand, London, W.C.2, who represent the Swiss engineering company of the same name, contain commercial and technical matter dealing with dynamos for telephone installations, pressure losses in exhaust bends of steam turbines, three-phase induction regulators, oil coolers and condensing plant, and electric locomotives. The firm, we understand, has obtained orders for 30 of the 57 electric locomotives required for the Swiss State Railways. These engines have single-phase motors and are designed for hauling 480-ton loads on gradients of 1 in 100 at a speed of 40 m.p.h.

Gas Plant.—An interesting and handsomely printed book has reached us from Messrs. Wests' Gas Improvement Company, Limited, Miles Platting, Manchester. It gives the history of the firm, which was founded fifty years ago, followed by an account of the various buildings, plant and equipment of the works at Miles Platting, which includes an experimental gas plant. Some of the firms' products such as stoking machines, coal elevating and conveying plant, retorts, &c., are described, and brief particulars are given of fifteen large installations of gas-making plant carried out by them. The book is well illustrated throughout.

Marine Propellers.—We have received from the Akimoff Propeller Company, Harrison-building, Philadelphia, Pa., a booklet describing in general terms the circulation theory of the operation of the screw propeller. This theory is used as the basis for designing the propellers supplied by the company. The blades of these propellers have accordingly "wing sections" instead of the segmental section commonly employed and the pitch is variable. A 8½-in. model propeller was tested in the model basin of the Navy Department, Washington, D.C., with highly satisfactory results, and the makers state that the full sized screws as applied to a twin screw vessel showed a propeller efficiency of about 82 per cent. at 12 knots and of about 79 per cent. at 21 knots. The corresponding propulsive coefficients were 72 per cent. and 66 per cent.

ASSOCIATION TECHNIQUE MARITIME ET AÉRONAUTIQUE.—This association informs us that meetings have been arranged for the reading and discussion of papers on June 4, 5 and 6, in the association's building, 7, Rue de Madrid, Paris.

COAL MINING IN MANCHURIA.—The Mining Bureau of Mukden has opened two coal mines in the district of Fengtien, west of the Liao River. The first, which is located to the west of Koupangtzu Junction on the Peking-Mukden Railway, has been in operation over a year. The initial expenses are already being repaid by the output of coal from the four working pits, writes the Takumen correspondent of the *North China Daily News*. Recently a trained mining engineer and staff have been sent, with adequate provision of funds, to bore for coal in a scientific way at or near a mine 13 miles west of Takumen. Preliminary surveys have shown that there is a wide coalfield in the neighbourhood. At present the operations are hampered by a considerable depth of water. If the yield turns out as satisfactory as is expected, this mine will, like the first, be connected with the Peking-Mukden Railway. To the nearest station, Hsinmintun, a line of some 53 miles would be required.